PATENT SPECIFICATION

(11) 1 214 330

DRAWINGS ATTACHED

1 214 330

(21) Application No. 11077/68 (22) Filed 7 March 1968

(31) Convention Application No. 622 749 (32) Filed 13 March 1967 in

(33) United States of America (US)

(45) Complete Specification published 2 Dec. 1970

(51) International Classification B 29 d 23/12

(52) Index at acceptance

F2P 1A35 1B3 1B7 2A2 2C10 2C2 2C3 2C5 2C7

(54) APPARATUS FOR MAKING A LAMINATED PIPE COVER

(71) We, BALDWIN-EHRET-HILL, INC., a corporation of Pennsylvania, United States of America, of 500 Breunig Avenue, Trenton, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for making a laminated pipe covering.

Some of the characteristics desired in a pipe covering for insulating conduits or the like include good compressive strength characteristics, a predetermined amount of resiliency, a resistance to abrasion and, of course, economy in manufacture. Some of the pipe covering now produced does not meet the various desiderata mentioned above. For example, some pipe covering is made from mats of mineral wool which are spirally wound to a predetermined cross-section and then cured and others are of a similar construction except that they are made entirely of glass fibre. A number of serious deficiencies have been noted in practical applications of heavy density pipe covering made from straight mineral wool; namely, lack of abasion resistance resulting in damage to the surface not only during shipping but also during the packaging operation at the plant, lack of sufficient resiliency and mechanical strength causing severe damage to the ends of the pipe covering during shipping and handling and in some instances breakage at the construction site. Additionally, it has been noted that straight mineral wool laminates show not only a high amount of surface abrasion, but also delamination and breakage along the hinges. Laminated pipe covers made from low cost glass fibres have benerally the same characteristics as those made of mineral wool noted above, that is, poor resistance to abrasion, tendency to delaminate and break along the hinge and others. On the other hand, the use of better grade glass fibres to make a laminated pipe cover laminated in the density range required to provide the necessary degree of compressive strength is prohibitively expensive.

Previous systems and apparatus for making laminated pipe covering consisted of a supply station where a log of mineral wool or glass fibre was rotatably mounted and which was selectively movable relative to a fixed saw so that a mat was severed from the outer periphery, this mat being delivered to and helically wrapped around a mandrel. After a predetermined build-in, the product was cured and stripped from the mandrel.

Some difficulties were encountered in making pipe covering in apparatus of this type and included the following. For example, by mounting the log for movement relative to the saw, it was found difficult to obtain a mat of uniform thickness and accordingly, it was difficult to control the final wall size and density of the pipe covering. Furthermore, in these apparatus the mandrel was usually rotated at a predetermined fixed speed and thus during build-up of the mat on the mandrel the mat had a tendency to stretch and in some cases tear since the peripheral speed during build up was different from and greater than the linear feed speed of the mat. This, of course, affected density and uniformity of cross-section of the finished pipe covering and in some cases, where the mat tore, the machine cycle of operation had to be interrupted. Additionally in these apparatus it was observed that the central opening in the pipe covering was not of circular cross-section and varied from one covering to the next made on the same mandrel. This, of course, resulted in rejects for the reason that if the central opening is not accurate, it cannot be used for a given size conduit since it must closely conform to the size and circular shape of the conduit to provide an effective insulation.

Embodiments of the apparatus of the present invention overcome the disadvantages and difficulties of the prior apparatus

[Price 5s. 0d. (25p)]

discussed above and are effective to produce pipe covering wherein the cross-sectional size and shape may be controlled accurately.

According to the invention apparatus for making a laminated pipe covering comprises a transfer conveyor for delivering at least one mat to a wrapping station, a mandrel at said wrapping station, actuating means for rotating the mandrel whereby the mat is wrapped on the mandrel, means for selectively varying the rotational speed of the mandrel during build up on the mandrel so that the peripheral speed of the mat is substantially equal to the feed speed of the transfer conveyor. According to a modified form of apparatus there is provided a first supply station wherein a log of a first fibrous material (such as glass fibre) is rotatably mounted, a second supply station wherein a log of a second material (such as mineral wool) is rotatably mounted, cutting means at each supply station for cutting a mat of predetermined thickness from the outer periphery of each log, transfer conveyor means for delivering the superimposed mats to a wrapping station where the mats are spirally wrapped on a mandrel, and means for curing the so wrapped mats to form a pipe covering. In the present instance, the cutting means are mounted for controlled movement relative to the log to cut a mat of uniform thickness continuously from the peripheral edge thereof thereby providing the desired control of the wall thickness and of the ratio of first to second materials.

The means provided for selectively varying the rate of rotation of the mandrel during the wrapping cycle so that the peripheral speed of the material being wound on the mandrel is substantially equal to the linear feed speed of the mats prevents stretching, tearing, or bulging of the mats during wrap up. This arrangement also ensures a close control of the density, wall size and ratio of one mat to the other in the finished product. The apparatus further includes means for ensuring a tight wrap of the mats on the mandrel to provide a circular central opening of predetermined size in the finished product, this means including a wax applicator which deposits a line of wax on the mandrel which secures the lead edge of the mats during the first wrap tightly on the mandrel and a stuffing mechanism which tucks the lead edge of the mats tightly against the mandrel in the first wrap.

The invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which

Figure 1 is a perspective view of a section of pipe covering made on apparatus in accordance with the invention,

Figure 2 is an enlarged sectional view through the pipe covering taken on lines 2—2 of Figure 1,

Figure 3 is a perspective view of a section of pipe covering showing a radial slit through one wall and a partial slit through the other wall,

Figure 4 is a perspective view of the pipe covering in an open position ready to be applied over a conduit,

Figure 5 is a schematic illustration showing the broad principle of operation an apparatus in accordance with the invention,

Figure 6 is a side elevational view showing the structural details of the apparatus for making pipe covering,

Figure 7 is an enlarged end view of the apparatus of Figure 6 looking in from the supply station end thereof,

Figure 8 is an enlarged partial view of the rear supply station taken along the line 8—8 of Figure 6,

Figure 9 is an enlarged fragmentary view taken along the line 9—9 of Figure 7 showing adjusting means for the cutting blade of a saw assembly,

Figure 10 is a fragmentary view showing part of the drive system for one of the saw assemblies taken on the line 10—10 of Figure 7,

Figure 11 is an enlarged fragmentary sectional view taken on the line 11—11 of Figure 8,

Figure 12 is an end elevational view as viewed from the right-hand end of the apparatus with respect to Figure 6,

Figure 13 is a view of the wrapping station of the apparatus as viewed along the line 13—13 of Figure 6,

Figure 14 is a fragmentary plan of the drive system of the apparatus for rotating logs at the supply stations,

Figure 14*a* is a schematic view of the drive connection for a back-up roll assembly of the apparatus,

Figure 15 is an enlarged fragmentary view of the wrapping station showing the relative position of the parts during the curing cycle,

Figures 16 to 21, inclusive, are enlarged sectional views taken on the lines 16—16, 17—17, 18—18, 19—19, 20—20 and 21—21, respectively, of Figure 15,

Figure 22 is a sectional view taken on the line 22—22 of Figure 21,

Figure 23 is a side elevational view partly in section of the wrapping station at the start of a wrapping cycle with a predetermined section of the superimposed mats in position to be wrapped on the mandrel at the start of a wrapping cycle,

Figure 24 is a view similar to Figure 23 showing the lead portion of the mats in their first wrap around the mandrel the stuffer in position to engage the lead edge of the mats,

Figure 25 is a fragmentary view showing a stuffer mechanism of the apparatus tucking in the lead edge of the mats around the mandrel,

Figure 26 is a view similar to Figure 25 showing the relative position of the parts at cutoff,

Figure 27 is a fragmentary view of the wrapping station with the back-up roll and support conveyor assembly during the curing cycle,

Figure 28 is an enlarged sectional view taken on the line 28—28 of Figure 27,

Figure 29 is a view taken along the line 29—29 of Figure 28,

Figure 30 is a view similar to Figure 29 showing the finished pipe cover being ejected from the mandrel, and

Figure 31 is a sectional view of a wax applicator taken along the line 31—31 of Figure 30.

Referring to the drawings, a hollow tubular pipe cover generally designated by the numeral 10 of the type produced by the apparatus in accordance with the present invention is shown in Figures 1—4 inclusive. The pipe cover 10 as best illustrated in Figure 2, is a laminated construction comprising a plurality of layers of fibrous material which are bonded and interlocked to one another to provide a unitary structure. In the present instance the pipe cover 10 is formed by spirally winding superimposed mats of different fibrous materials into a tubular form, the outer layer L_f and every other layer being made of glass fibre and the intermediate layers L_m between the glass fibre layers being made of mineral wool. As best illustrated in Figures 3 and 4, the pipe cover 10 has a longitudinally extending slit 12 through the sidewall and a partial slit 14 diametrically opposed therefrom dividing the pipe cover in halves 10*a* and 10*b* connected by a hinge 16 so that it may be opened as illustrated in Figure 4, to facilitate assembly to a conduit or the like.

It has been found that optimum functional characteristics combined with maximum economy are provided in a pipe cover when the glass fibre content is between about 10% and 35% with the mineral fibre content comprising the balance, and the density of the finished cover is in the range of about 4.5 to 8.5 lbs/ft^3. More specifically in this range the laminated pipe cover has physical characteristics comparable to those of straight glas fibres; that is, good resiliency providing excellent handling characteristics during shipping and installation, a stable integrally bonded structure wherein the layers do not tend to delaminate, and good dimensional stability under conditions of variation. Furthermore, the laminated pipe cover is extremely economical and the outer layer of glass fibre provides a reliable hinge which does not crack or break.

To provide an understanding of the operations of an apparatus for making the pipe covering, a brief description of the operation as schematically shown in Figure 5 and Figures 23—27, inclusive, will be presented indicating broadly the various stations of the apparatus at which various operations are carried out. Considering now the apparatus in terms of function, there are two supply stations, F_1 and F_2, a log 20 of a first fibrous material, glass fibre impregnated with a suitable thermosetting binder, being rotatably mounted at the first log station F_1 and a log 22 of a second fibrous material, mineral wool impregnated with a suitable thermosetting binder, being rotatably mounted at the second supply station F_2. A band saw assembly having an endless cutting blade 24 is provided at the first supply station, the upper run of the blade being movable radially relative to the log 20 at a predetermined rate to cut a mat 26 of predetermined thickness from the outer periphery thereof. A similar band saw assembly having an endless cutting blade 28 is provided at the second supply station F_2, the upper run of the blade being movable radially relative to the log 22 at a selected rate to cut a mat 30 of predetermined thickness from the outer periphery thereof.

The glass fibre mat 26 is deposited on an endless belt 32 of a first conveyor system 33 and then transferred to the endless belt 34 of a second conveyor system 35, the mineral wool mat being superimposed on the glass fibre mat 26 as it is cut from the log 22. The conveyor belt 34 delivers the mats 26 and 30 through a cut-off station C_s to a wrapping station W_s which includes a rotatably mounted mandrel assembly 50 and a back-up belt assembly 52 to urge the mats against the mandrel during build up thereof on the mandrel.

Considering now briefly the operation of the apparatus to produce pipe covering of the type illustrated in Figures 1—4 inclusive, a drive system effects rotation of the logs 20 and 22 and operation of the conveyors 33 and 35. As each log rotates, the saw assemblies are continuously operated in a controlled manner to advance radially relative to the logs thereby to continuously cut a mat of predetermined, substantially uniform thickness and deliver it to the conveyor belts 32 and 34, respectively. At the start of operation the back-up belt assembly 52 is in a lowered position (see Figure 23) and after the lead edge of the mats is advanced along the upper support run of the belt of the back-up assembly a predetermined distance relative to the mandrel, the back-up assembly is actuated to a raised position (see Figure 24) and simultaneously

a stuffer mechanism 54 is actuated downwardly toward the mandrel 50. Thereafter, the stuffer mechanism 54 engages the lead edge of the mats 26 and 30 and stuffs it tightly against the mandrel (see Figure 25). After a predetermined wrap-up period depending on the final desired wall section of the pipe covering, automatic control means effects actuation of a cut-off gate 56 at the cut-off station C_S to its lowered position, deactuation of the feed conveyors 33 and 35, and initiation of the curing cycle. During this period, the mandrel 50 continues to rotate at a predetermined first speed. After a predetermined pre-sizing cycle, the mandrel speed is increased and a gas burner is switched from low to high flame, and hot air is admitted into the mandrel for the final curing operation. At the completion of the final curing cycle, the mandrel 50 is deactuated, the burner is cut off and the back-up belt assembly 52 moved to its lower position. Thereafter, a stripper assembly ejects the finished pipe covering from the mandrel and the cycle is automatically repeated.

Various prime actuators such as motors and hydraulic piston-cylinders, and control elements, such as a cycle programmer including timers, counters, and switches, which will be described in detail hereafter in connection with the detailed description of the specific construction of the apparatus, are provided for effecting operation of the apparatus, are provided for effecting operartion of the apparatus in the manner described above.

With the foregoing general description in mind, the particular contruction and operation of the apparatus will be considered starting with the first supply station F_1 and considering the other stations of the apparatus in the sequence in which encountered by the mats 26 and 30 as they pass through the apparatus.

The details and arrangement of the first and second supply stations are substantially identical and thus, identical parts at each have the same reference numeral, except the parts of the second station have a subscript "a".

Considering now the first supply station, and particularly with reference to Figures 6 and 7, the log 20 is mounted on a shaft 70 which in the present instance is supported for rotation about a fixed axis on "live centres" to facilitate easy removal and replacement of a spent log when necessary. The live centre support arrangement consists of an adjustable screw member 80 engageable in one axial end of the log shaft 70 and a hydraulic piston-cylinder actuator 86 having a piston rod 88 engaging in the opposite axial end of the shaft 70. The screw member 80 which is engageable in one end of the shaft 70 is adjustable axially in an internally threaded sleeve 82 mounted on a bracket supported at the upper end of an upright stanchion 84 projecting upwardly from the base B of the main frame structure of the machine. The hydraulic actuator 86, which is mounted on a bracket supported on an upright stanchion 90 projecting upwardly from the opposite side of the base of the machine, is provided with a solenoid control valve and is suitably connected to a source of fluid pressure so that the piston rod 88 may be cycled between the extended position supporting the shaft 70 shown in Figure 7 and a retracted position when it is desired to replace the log.

The log 20 is rotated about the axis of the log shaft 70 by means of a log hold-down and actuating assembly generally designated by the numeral 91 consisting in the present instance of a pair of slightly curved support arms 92 and 94 on opposite sides of the log which are pivotally mounted at their lower ends as at 96 and 98 on a shaft 99 journalled at its opposite ends in bearing mounts 101 and 103 mounted on the upper ends of the stanchions 84 and 90, respectively. The support arms rotatably support therebetween a series of rolls and rollers mounting an endless belt 102 for movement in an endless path. More specifically, the belt support includes a drive roll 105 having the usual pintles or trunnions 107 and 109 at opposite axial ends rotatably supporting the drive roll 105 between the arms 92 and 94, a driven roll 111 and a pair of guide rollers 113 and 115. The trunnion 109 mounts a sprocket 117 at its outer end which in turn is actuated by a drive system described in detail below to actuate the belt and thereby rotate the log. The log hold-down and actuating assembly 91 is normally urged in a downward direction to press or seat the belt 102 against the log by means of a pair of hydraulic piston-cylinder actuators 104, the piston rod 121 of each being connected to one of the support arms and the cylinder 123 being pivotally supported to one of the stationary stanchions (see Figure 6). The actuators 104 are connected to a suitable source of fluid pressure through lines including a solenoid control valve whereby the back-up belt assembly may be selectively moved between a lowered position engaging the log during operation of the apparatus and a raised position to change a log when it has been spent. By this arrangement, the control valves for the hydraulic actuators 104 effect flow of fluid to retract the piston rods into the cylinder thereby to press the back-up belt against the outer periphery of the log and effect rotation of the log through rotation of the back-up belt. Of course as the log decreases in size during cutting of the mat from the outer periphery thereof,

the actuators 104 pivot the back up belt assembly downwardly to maintain continuous engagement with the outer periphery of the log. When it is necessary to replace a log, flow of fluid to the actuators 104 is simply reversed to move the hold-down assembly out of the way and permit a new log to be inserted between the live centres.

In the present instance the saw assembly 106 is adapted for movement up and down relative to the base whereby the cutting blade is displaced radially relative to the log to cut a mat of predetermined thickness from the log during rotation thereof. The saw assembly, as best illustrated in Figure 7, comprises a pair of wheels 110 and 112 rotatably mounted in housings 114 and 116 on either side of the base of the apparatus and an endless band cutting blade 24 mounted for movement in an endless path between the wheels, the cutting blade 24 being actuated by means of a saw motor M connected in the present instance to the wheel 110 by means of a belt transmission 120. The wheel housings 114 and 116 are in turn supported on generally rectangular channel members 122 and 124, respectively, which circumscribe and are adapted for axial movement relative to generally cylindrical posts 126 and 128 extending upwardly on either side of the base of the apparatus. Roller guides 130 mounted at opposite ends of the channel members 122 and 124 guide movement of the saw assemblies on their respective channel members.

The saw assembly 106 is movable radially relative to the log so that the upper run R of the cutting blade 24 remains generally parallel to the axis of rotation of the log thereby to ensure cutting a mat of uniform thickness across the entire width of the log. To this end, a pair of rotatable upright jack screws 144 and 146 is provided on opposite sides of the base which engage in internally threaded members 140 and 142 carried by the wheel housings 114 and 116. The jack screws 144 and 146 are actuated by a common drive system including a motor M_1, a gear reducer 132 which drives actuating gears 150 and 152 at the lower end of the jack screw through an endless chain drive 154.

Actuation of the motor M_1 to effect movement of the saw assembly upward to cut a mat of desired thickness is controlled by a microswitch unit S containing a microswitch and a timer actuated by a sensing arm 164 disposed in the path of movement and engageable upon rotation of the log by four circumferentially equispaced cam elements 166 on the log shaft. By this arrangement during rotation of the log shaft 70 at a normal speed, the sensing arm 164 operates the timer thereby effecting operation of the motor M_1 to advance the saw blade assembly for a given time increment greater than the time required for adjacent cam elements 166 to engage the sensing arm 164. Thus, in normal operation, the saw assembly is continuously moving at a predetermined fixed rate relative to the log so that mats of uniform thickness are cut from the outer periphery thereof. When the log shaft stops rotating, for example, at cut-off of the mats prior to the curing cycle, the motor M_1 will stop movement of the saw assembly after a predetermined short time interval when the timer runs out. Of course, actuation of the saw assembly to advance the upper run of the saw blade takes place when the log shaft 70 starts to rotate again, for example, in the next feed cycle to the mandrel. Limit switches S_1 and S_2 operatively connected to the motor M_1 through a circuit are provided, the switch S_1 limiting downward movement of the saw assembly and determining its lower limit position and switch S_2 limiting upward movement to determine its upper limit position.

It is noted that the feed rate of each of the saw assemblies may be varied individually, for example, through the gear reducer to provide means for selectively varying the ratio of glass fibre to mineral wool in the finished product. This may also be accomplished through the timer in the microswitch units S and *Sa*.

The mat 26 cut from the log 20 is deposited on the transfer conveyor 33 which in turn delivers the mat to the transfer conveyor 35 at the second supply station F_2. The transfer conveyor 33 comprises an endless screen mesh belt 32 which is supported for movement in an endless path around a plurality of rolls, including a drive roll 175 rotatably supported on the outer ends of a pair of brackets 177 projecting forwardly toward the second supply station and secured at their inner ends to the stanchions 84 and 90 on opposite sides of the apparatus, a driven roll 179 rotatably journalled at its terminal ends in bearings 181 mounted on latch plates 183 which in turn are supported on the wheel housing for the saw assembly on opposite sides of the apparatus. The latch plates, which consist of two hinged leaves, permit small adjustments of the roll 179 by means of an adjusting screw 185 to vary the position of the upper run 187 of the conveyor belt relative to the upper run of the saw blade. The support system for the transfer belt further includes a pair of guide rollers 189 and 191 and a tension roller 193 carried by a support arm 195 pivotally mounted at one end to the stanchions and carrying at its outer end counterweights 197 to maintain the belt taut during displacement of the upper run of the belt from the full line to the broken line position shown in Figure 6.

The conveyor system 35 at the second supply station F_2 is slightly different from the conveyor system described above, the differences in construction being for the purpose of providing a continuous transfer link between the first and second supply stations. To this end, the conveyor system includes a pair of support brackets 201 projecting rearwardly from the side stanchions downwardly at an angle and rotatably supporting at their outer ends a roll 203 which overlies the outer end of the drive roll 175 of the first conveyor system whereby the upper run 205 of the second conveyor system is positioned to receive the material from the first conveyor system continuously.

The transfer conveyor 35 delivers the superimposed mats through the cut-off station *Cs* to the wrapping station W*s*. There is provided at the cut-off station *Cs* a cut-off assembly including an elongated cut-off blade 56 with a blunt lead edge having a plurality of spring fingers 202 connecting the blade 56 to a shank member 204. The cut-off blade is actuatable from its normally raised position (see for example Figure 23) during the wrapping cycle to a lowered position (see Figure 26) wherein the mats are severed by the blunt edge pressing against the drive roll 175*a* of the transfer conveyor 35 which is rotatably journalled between the side frame members of the back-up roll assembly for the mandrel. In the present instance the shank member 204 is mounted on guide rods 207, Fig. 21, secured to side plates 215 which mount a series of four rollers 217 straddling the leg portions 209 of an inverted U-shaped support bracket 206 which overlies the apparatus and is connected to sidewall sections 305 of the movable frame structure 303 of the back-up roll assembly. Springs 210 circumscribe the rods 207 to normally urge the cutting blade to a raised position. Actuation of the cutting blade assembly between upper and lower limit positions is controlled by means of a hydraulic piston-cylinder actuator 211.

Considering now the details and arrangement of the wrapping station W*s*, there is provided an elongated hollow mandrel 300 which extends transversely of the apparatus and is rotatably supported in the sidewall of the main frame, the mandrel being rotated by a drive system including a motor M_2 connected by a belt 302 to a gear reducer 304 and meshing gears 306 and 308 as illustrated in Figure 13. The free end of the mandrel 300 is supported during the wrapping cycle by means of a tailstock 310 which is adapted to engage over a conical pin 312 on the free axial end of the mandrel opposite the drive end, the tailstock 310 being connected by a parallelogram-type linkage 314 to a hydraulic piston-cylinder actuator 316. By this arrangement as shown in Figure 29, during the wrapping cycle the tailstock 310 engages over the conical pin 312 and supports the mandrel rotational axis and prior to ejection of a finished pipe cover the piston-cylinder actuator 316 pivots the tailstock through the linkage 314 to a retracted position shown in Figure 30 to permit ejection of a finished pipe cover.

Cooperatively associated with the mandrel 300 is a stripping mechanism generally designated by the numeral 320 consisting of an annular collar 322 circumscribing the mandrel and connected to the piston 324 of a hydraulic actuator 326. The stripper collar 322 normally is in the position shown in Figure 29 during the wrapping cycle and after the curing cycle is actuated axially relative to the mandrel to strip a finished pipe cover as shown in Figure 30 through the cycling of the hydraulic actuator 326. In the present instance, the piston 324 mounts a wax applicator 330, Fig. 31, consisting of a reservoir 332 for wax and a spray nozzle 339 having a tip or nozzle opening directed against the mandrel surface so that during ejection and cycling of the collar 322 a charge of wax is applied along a line the entire length of the mandrel. By this arrangement, when the mats are fed to the mandrel at the start of a wrapping cycle and the stuffer mechanism engages the lead edge thereof, the wax ensures a strong adhesion of the initial wrap of the mats on the mandrel to provide good conformity of the mats to the mandrel and ensures a concentric inner bore in the finished pipe cover.

The mats are pressed against the mandrel during the wrapping cycle by the back-up roll and belt assembly 52. The back-up roll and belt assembly comprises the movable frame structure 303 including the pair of spaced apart sidewall sections 305 and a support base 309 connecting the sidewall sections, and a plurality of rolls supporting a back-up belt 311 for movement in an endless path. The back-up rolls for the belt 311 includes a cluster of three rolls 319, 321 and 323 rotatably supported between the sidewall sections 305, a floating roll 325 rotatably journalled between the upper links 327 of a back-up control linkage system L and two lower rolls 329 and 331 mounted between the upstanding sidewalls of the main frame. The belt 311 of the back-up roll assembly is actuated in an endless path by motor M_5 through a drive connection including a sprocket 338, Fig. 14*a*, on the shaft of a gear reducer 400, a sprocket 334 on the roll 323 and a chain 336 connecting the sprockets. The back-up roll assembly 52 is actuatable between a lower limit position (see Figure 23) and an upper limit position (see Figure 24) by means of a pair of jack screws 333 engageable in jack screw housing 337. The jack screws 333 are actu-

atable in the housing to move the back-up assembly between limit positions by a common drive motor M_3 connected by a belt transmission 341 to a shaft 343 which mounts worm gears to drive the jack screws. Limit switches S_3 and S_4 operatively associated with the motor M_3 determine the upper and lower limit positions of the back-up roll assembly 52. For example, the lower limit switch S_3 engages the lower side of a platform 335 when the back-up assembly is raised and the upper limit switch S_4 engages the upper side of the platform 335 when the assembly is lowered (see Figure 13). The jack screw housings 337 are supported on the platform 335, which forms part of the main frame which abuts the support base 309 of the back-up roll assembly 52.

The belt for the back-up roll assembly is a wire mesh belt and has a tendency to pick up fibres from the mats. Accordingly, a rotating brush cleaner 531 is provided which is driven through a belt transmission 533 connected to a motor M_4.

The back-up control linkage system L is pivotally supported between angularly offset arms 351 depending from the sidewall sections 305. The linkage system L controls various cycles of the apparatus such as termination of the wrapping cycle, actuation of the cutting blade assembly and variation in the mandrel speed during the wrapping and curing cycles as explained in more detail hereafter. Thus, the linkage system includes a shaft 361 rotatably supported between the terminal ends of the side frame extension arms 351, upright linkage arms 363 secured at opposite ends of the shaft and the upper links 327 connected to the outer free ends of the linkage arms 363 which in turn rotatably support at their outer ends the floating roll 325 defining one end of the wrap run of the wrap up belt. Shaft 361 also mounts a counterweight 361*a*. One of the upright linkage arms 363 also mounts an adjustable bracket 365 having an arcuate slot 366 within which engages a locking screw 368 permitting angular adjustment of the roll 325 relative to the arm 363. The axle 367 of the shaft 361 mounts a connecting link 369 which is connected by a link 371 to a gear wheel 373 which meshes with a gear 376 of a potentiometer 379. The potentiometer 379 is operatively associated with the mandrel motor actuator M_2 and is operative to selectively vary the rotational speed of the mandrel upon rotation of the gear wheel 373.

By this arrangement, during the wrapping cycle, as the mat build-up on the mandrel increases, the floating roll 325 is urged outwardly which in turn pivots the linkage arm 363 in a clockwise direction whereby the gear wheel 373 rotates a small angular increment. However, rotation of the wheel 373, as noted above, effects through the potentiometer 379 a decrease in the rotational speed of the mandrel during build-up and at a rate so that the peripheral speed of the mats is approximately equal to the linear feed speed of the second transfer conveyor belt and the belt of the back up assembly thereby ensuring a uniform build up of a mat on the mandrel. Further, as the link arm is pivoted outwardly and at a predetermined build-up of the pipe cover on the mandrel, a cam 381 engages a microswitch S_7 adjustably mounted on the main side frame and connected through a circuit including a timing control element to the actuator for the cut-off blade to sever the mats when the desired amount has been wrapped to produce a cover of predetermined cross-section. Of course, the microswitch S_7 may be selectively adjusted relative to the frame to vary the point of cut-off thereby to provide a means for varying the cross-section of the finished pipe cover for a given size mandrel or for changing from one size mandrel to another size.

The linkage system further includes an arrangement for guiding the floating roll 325 of the back-up assembly to position it properly relative to the mandrel upon actuation of the back-up assembly from a lowered position (see Figure 23) to its upper or raised position (see Figure 24). To this end, there is provided a vertical linkage arm 391 at one side of the apparatus which is pivotally connected to the main side frame as at 393, an upper linkage arm 395 pivotally connected at one end to the vertical linkage arm 391 and pivotally connected at its opposite end at about the midpoint of a pivot arm 397 which in turn at its lower end is pivotally connected to the side frame as at 399. The upper end of the pivot arm 397 mounts a guide roller 401 engageable at a predetermined point in the wrap up cycle with the lower portion of a curved elevating cam 403 supported in a predetermined fixed position relative to the mandrel. An adjustable screw-type follower 405 is mounted in a bracket 407 fixed to the sidewall of the main frame which engages and follows the elevating cam 403 during movement of the back-up roll assembly from raised to lowered positions (see Figures 23 and 24).

The stuffer mechanism 54 is mounted on a bar 500 extending transversely of the apparatus and pivotally supported at the upper end of a support frame extension 502 of the main frame assembly. The stuffer mechanism includes an elongated tucking arm 504 of arcuate cross-section supported at the centre thereof on a piston 506 of a hydraulic piston-cylinder actuator 508 carried by the bar 500 and a pair of side thrust support members 510, each consisting of an elongated hollow sleeve 512 projecting from the bar 500 and a guide rod

514 telescoped in the sleeve connected to the tucking arm 504 adjacent opposite ends thereof. The actuator 508 is connected through suitable lines including a control valve to a source of fluid power and operates to effect movement of the tucking arm 504 toward and away from the mandrel. The stuffer mechanism 54 includes a second hydraulic actuator 516 supported on the side frame extension 502 having a piston 518 connected to a bracket 520 on the rod 500 whereby actuation of the piston 518 effects pivotal movement of the rod 500 and in turn pivotal movement of the tucker arm 504 relative to the mandrel periphery. An adjustable screw stop 523 engageable between the bracket 520 and a support bracket 525 for the cylinder 527 of the actuator 516 limits pivotal movement of the stuffer mechanism in a counterclockwise direction with respect to Figure 6. A limit switch S_8 is mounted on the cylinder 509 of the actuator 508 engageable by a tripping element 511 carried by a rod 513 to reverse fluid flow in the cylinder 509 and retract the stuffer arm from its lower stuffing position. Thus, in operation when the lead edge of the mats are in the initial wrap on the mandrel as shown in Figure 24, the actuator 516 rotates the stuffer assembly a small angular increment in a clockwise direction relative to Figure 6 and the actuator 508 moves the tucking arm 504 radially toward the mandrel. At the end of the stroke when the tuncking arm 504 overlies the lead edge of the mats on the mandrel, the actuator 516 pivots the entire assembly so that the tucking arm 504 presses the lead edge of the mats against the mandrel. In this position the tripping element 511 engages switch S_8 to retract the stuffer mechanism.

In the present instance a gas burner 537 is located under the mandrel to direct a curing flame along the length of the mandrel directed against the material thereon as best illustrated in Figure 28. The gas burner includes a control circuit for initiating and regulating the flame.

A drive system is provided for effecting actuation of the back-up belt assemblies and transfer conveyors at each supply station from a common drive source. The details of the drive system are best shown in Figure 14 and comprise a drive train including a plurality of interconnected chain drives connecting the drive roll for the back-up conveyor assemblies and the drive rolls for the transfer conveyors at the stations F_1 and F_2 to a common motor M_5. More specifically, the output shaft of the motor M_5 is connected through a belt transmission 402 to the gear reducer 400, the gear reducer output shaft in turn mounting a sprocket 404 which through a chain 505 drives a sprocket 507 mounted on the free running portion 406 of an electromagnetic clutch 408. By this arrangement when the clutch 408 is engaged, the transfer conveyor 35 is actuated. The free running portion 406 of clutch 408 also carries a transfer sprocket 409 which through chains 411 and 413 and sprockets 415 and 417 of a scissor bar linkage 419 drives a sprocket 421 mounted on the outer end of shaft 99*a*. Shaft 99*a* also mounts an electromagnetic clutch 429, the free running portion 431 of which is connected by a chain drive 433 to the drive roll 105*a* of the back-up conveyor assembly for the log 22. By this arrangement the log and transfer conveyor of the second supply station F_2 may be actuated by engaging the clutches 408 and 429.

Shafts 99 and 99*a* are connected by a chain 423 and sprockets 425 and 427 mounted on shafts 99*a* and 99, respectively. Shaft 99 also mounts an electromagnetic clutch 441, the free running portion 443 of which is connected by sprockets 445 and chain drive 447 to the sprocket 117 carried by the trunnion 109 of the drive roll of the first conveyor assembly. The free running portion 443 of the clutch 441 also mounts a sprocket 451 connected by chain drive 453 to the drive roll 175 of the transfer conveyor 33 at the first supply station F_1. By this arrangement it is apparent that the log and transfer conveyor at the first supply station may be actuated through the drive train independently of the log and conveyor at the second supply station and vice versa. It is clear also that the logs and transfer conveyors at both supply stations may be operated together from the common drive motor M_5 simply by engaging all of the electromagnetic clutches.

Considering now the operation of the pipe covering apparatus described above, assume that a new log 20 of glass fibre is mounted at the first supply station F_1 and a new log of mineral wool is mounted at the second supply station F_2 and that the respective cutting saw assemblies are in their lower limit position. Also at the start of operation, the back-up roll assembly 52 is in its lowered position as shown in Figure 23 and the cut-off gate 56 is in a lowered position. Programming of the machine cycles is controlled by means of cycle programmer identified Pc including a multi-cam, multi-position stepping switch control designated schematically as X in Figure 6, three timers designated Y1, Y2 and Y3, a counter mechanism designated Z and a plurality of control switches described above in connection with the detailed description of the apparatus. This control system effects predetermined operation of various actuators, such as the motors and hydraulic actuators.

At the start of operation all of the selector switches are in automatic position and

the apparatus is stopped, the stepping switch X being, therefore, in position 1. Now in order to start the apparatus, the start button O_S is depressed whereby the stepping switch advances to position 2 which effects operation of the hydraulic actuator 211 for the cut-off gate 56 to raise it to its upper limit position and starts motor M_2 to rotate the mandrel 50 at a predetermined angular speed. Simultaneously, jack screw motors M_1 and $M_{1}a$ for the saw assemblies, motor M_4 for the cleaning brush 531 and the main drive motor M_5 for the drive train actuating the back-up conveyors and transfer conveyors at the first and second log stations are started. Accordingly, the logs start to rotate and the saw assemblies at each station are automatically advanced to cut the mats 26 and 30 and deliver them on the conveyors toward the wrapping station W_S. It is noted that the cam elements 166 on the log shaft and the sensing arm 164 of switch unit S effect continuous movement of the saw assemblies during rotation of the logs and that the feed rate of the saw assemblies may be varied by adjusting the gear reducer to provide a means for varying the relative amounts of glass fibre and mineral wool in the finished product.

After a predetermined lead section of the superimposed mats is advanced beyond the cut-off station C_S to approximately the position shown in Figure 23 to provide a single wrap around the mandrel as measured by the counter Z, the stepping switch is advanced to position 3 which temporarily stops the main drive motor M_5 for the transfer conveyors and initiates operation of the jack screw motor M_3 to move the back-up roll assembly to its upper limit position (see Figure 26). As noted previously when the upper limit switch S_3 engages the bottom of the platform 335, the jack screw motor M_3 shuts off and the back-up roll assembly 52 is in its upper limit position.

Further, with the stepping switch X in position 3 actuation of the hydraulic actuator 316 for the tailstock 310 is effected to pivot the tailstock to a position supporting the outer end of the mandrel. Position 3 of the stepped switch X also effects actuation of the hydraulic actuators 508 and 516 for the stuffer mechanism 54 in the manner described above.

Actuation of upper limit switch S_3 of the back-up roll assembly advances the stepping switch X to position 4 which re-starts drive motor M_5, which in turn effects rotation of the logs and movement of the transfer conveyors at the first and second supply stations. At this point the tucking bar 504 of the stuffer mechanism is disposed adjacent the periphery of the mandrel in a position to tuck the lead edge of the mats in the nip between the mandrel and the belt and as noted previously, effect actuation of limit switch S_8 which reverses flow in the hydraulic actuator 508 to retract and raise the stuffer mechanism to its upper limit position.

The wrapping cycle now continues whereby the mats are spirally wound on the mandrel. During build up of the mats on the mandrel, the linkage assembly L pivots about shaft 361 which continuously effects small angular displacement of the gear wheel 373 which through the potentiometer 379 gradually decreases the rotational speed of the mandrel during build up. This control arrangement is such that the peripheral speed of the mats during build up is substantially equal to the linear feed speed of the transfer conveyors to eliminate the possibility of tearing of the mats during the wrapping cycle. In this way size and density of the finished pipe covering may be accurately controlled.

During build up of the mats on the mandrel, the linkage L pivots in a clockwise direction with respect to Figure 6 and at a predetermined point in the cycle, the cam 381 engages the limit switch S_7 which advances the stepping switch X to position 5 and in turn effects actuation of the cut-off gate 56 to its lower limit position through the hydraulic actuator 211, disengages the clutches for the transfer conveyors and log actuator assemblies and starts the gas burner 537 on low flame. Position 5 of the stepping switch also starts the timers Y_2 and Y_3. It is noted that during this period the mandrel continues to rotate at a predetermined speed to finish wrapping the trail edge of the mats. After a predetermined time as controlled by the timer Y_2, the stepping switch X is advanced to position 6 increasing the mandrel speed, increasing the belt speed of the back-up roll assembly 52, and switching the gas burner from low to high flame for the curing cycle. At a later time in the cycle as determined by timer Y_3, the stepping switch X is advanced to position 7 which stops the mandrel motor M_2 and belt motor M_3 and initiates operation of the jack screw motor M_3 for the back-up assembly to lower it to its lower limit position. When the back-up roll assembly reaches its lower limit position, lower limit switch S_4 stops the motor M_3 and initiates the hydraulic actuator 326 to cycle the collar 322 and strip the finished pipe covering from the mandrel.

When the stripping collar 322 reaches its outer limit position adjacent the free terminal end of the mandrel and the finished cover is ejected, proximity switch S_5 reverses flow in the hydraulic actuator 326 to retract the stripping collar 322 and on the retract stroke the collar engages limit switch S_6, advances the stepping switch X to posi-

tions 9, 10, 11, and 12 and actuates timer Y_1. Timer Y_1 advances the stepping switch to position 2 to re-cycle the apparatus. Pipe covering is continually produced in this manner until the stop push button Of is actuated to stop the entire machine.

The various actuators include a solenoid responsive to an electrical control signal to effect cycling thereof through the programmer in the manner and sequence described above.

While a particular embodiment of the present invention has been illustrated and described herein, it is not intended to limit the invention to such disclosure and changes and modifications may be made therein within the scope of the following claims.

WHAT WE CLAIM IS: —

1. Apparatus for making a laminated pipe covering, comprising a transfer conveyor for delivering at least one mat to a wrapping station, a mandrel at said wrapping station, actuating means for rotating the mandrel whereby the mat is wrapped on the mandrel, and means for selectively varying the rotational speed of the mandrel during build up on the mandrel so that the peripheral speed of the mat is substantially equal to the feed speed of the transfer conveyor.

2. Apparatus as claimed in claim 1, comprising at least one supply station, a log of fibrous material rotatably mounted at said supply station, cutting means at said supply station for cutting said mat with a predetermined thickness from the outer periphery of the log.

3. Apparatus as claimed in claim 1, comprising first and second supply stations, a first log of fibrous material rotatably mounted at said first supply station, a second log of fibrous material rotatably mounted at said second supply station, cutting means at each of said supply stations for cutting a mat of predetermined thickness from the outer periphery of the log at each station, transfer conveyor means for transferring the mats superimposed one on the other to a wrapping station, a mandrel at said wrapping station, means for spirally winding the superimposed mats around the mandrel at the wrapping station and means for curing the so wrapped mats to form it into an integral pipe covering.

4. Apparatus as claimed in claim 3, comprising a stuffer mechanism at said wrapping station having a tucking arm and means for actuating the tucking arm to a position engaging the lead edge of the superimposed mats in the first wrap of the mats on the mandrel.

5. Apparatus as claimed in claim 3 or 4, comprising a backup assembly having a belt mounted for movement in an endless path supporting the mats during build up on the mandrel.

6. Apparatus as claimed in claim 5, comprising a motor drive for said mandrel, a speed control means and a linkage operatively connected with the back-up assembly and said speed control device so that upon build-up of the mats on the mandrel the linkage is pivoted which through the speed control decreases the speed of rotation of the mandrel.

7. Apparatus as claimed in claim 6, wherein the speed control means comprises a gear wheel connected to the linkage and operable for limited angular movement upon movement of said linkage during build up and a potentiometer operatively associated with said gear wheel and said motor actuating means for the mandrel.

8. Apparatus as claimed in any of claims 5 to 7, wherein said back-up assembly is selectively actuatable between an upper limit position to back up the mats during build up and a lower limit position and including switch control means for determining the upper and lower limit positions.

9. Apparatus as claimed in any of claims 1 to 8, comprising a stripping mechanism including a collar surrounding said mandrel and a piston-cylinder actuator operatively connected to said collar to cycle the same and effect discharge of finished pipe covering from the mandrel.

10. Apparatus as claimed in claim 9, comprising a wax applicator operatively associated with said collar adapted to deposit a line of wax on the mandrel.

11. Apparatus as claimed in any of claims 3 to 8, comprising control means for selectively actuating said cutting means radially relative to each log to continuously cut a mat of predetermined uniform thickness during rotation of said log.

12. Apparatus as claimed in claim 11, wherein each log is mounted on a log shaft and wherein said control means for said cutting means comprises a microswitch unit including a sensing arm, a timer and a plurality of cam elements carried by said log shaft engageable with said sensing arm to control actuation of said cutting means.

13. Apparatus as claimed in any of claims 3 to 12, comprising a hold-down belt assembly for actuating each of said logs and a drive system for actuating said hold-down belt assembly and said transfer conveyor means from a common drive source including a drive train consisting of a plurality of interconnected sprockets and chains and a plurality of clutches in said drive system whereby the hold-down belt assembly and the transfer conveyor means at each supply

station may be actuated simultaneously or independently.

14. Apparatus for making a pipe covering constructed and arranged substantially as herein described with reference to Figures 5 to 31 of the accompanying drawings.

J. Y. & G. W. JOHNSON,
Furnival House,
14—18 High Holborn,
London, W.C.1,
Chartered Patent Agents,
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1970.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

FIG.1.

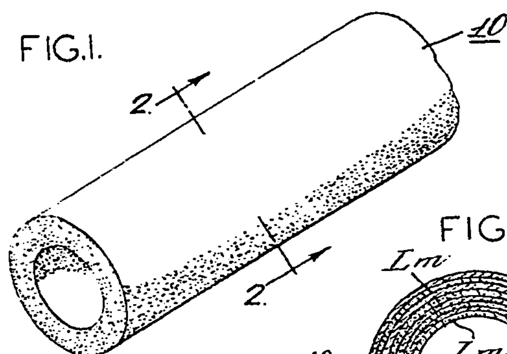


FIG.2.

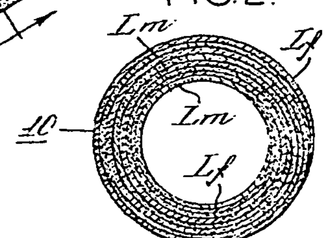
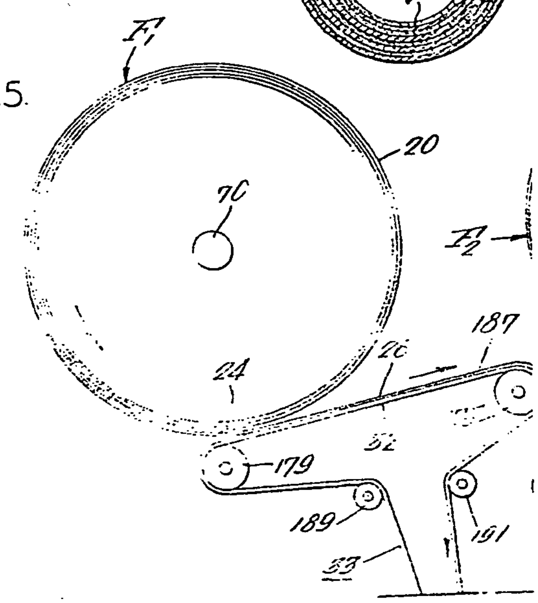


FIG.5.



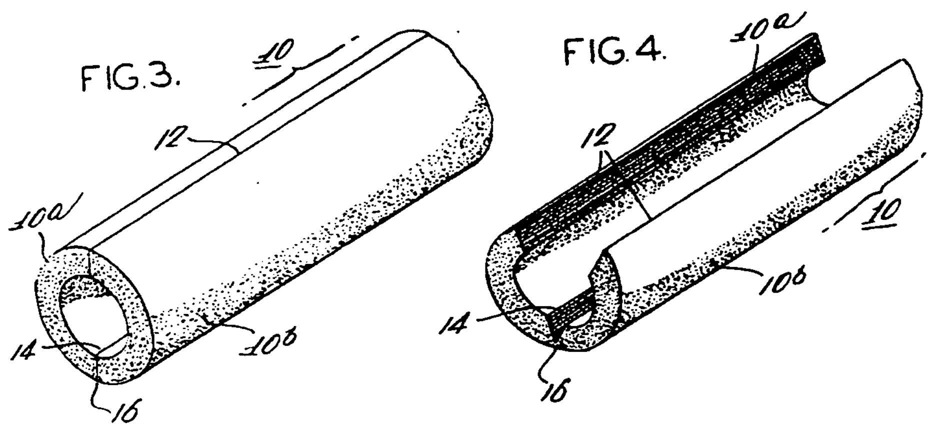
1214330 COMPLETE SPECIFICATION

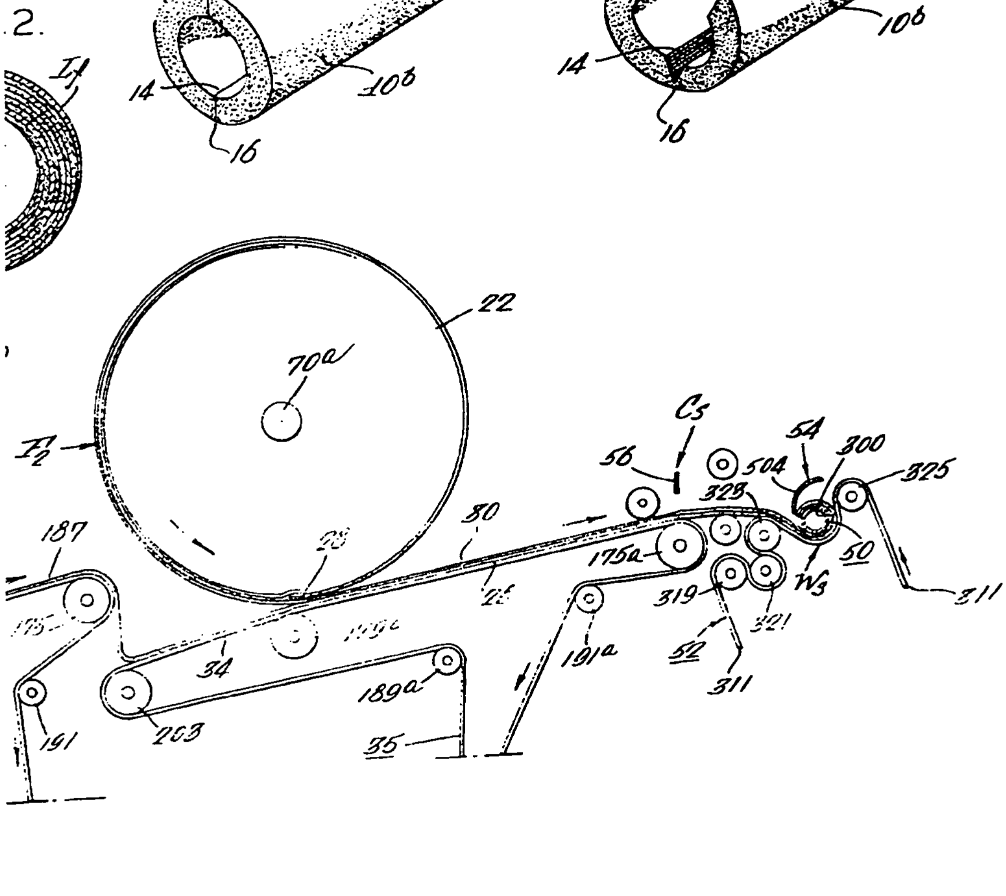
9 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1

FIG.3.

FIG.4.





1214330 COMPLETE SPECIFICATION

9 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1

FIG.1.

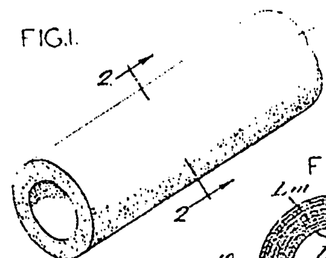


FIG.2.

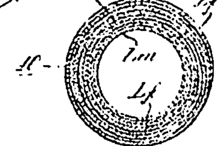


FIG.3.

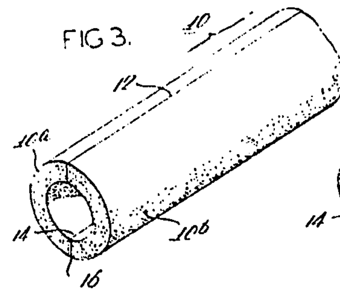


FIG.4.

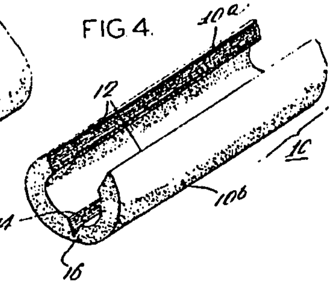
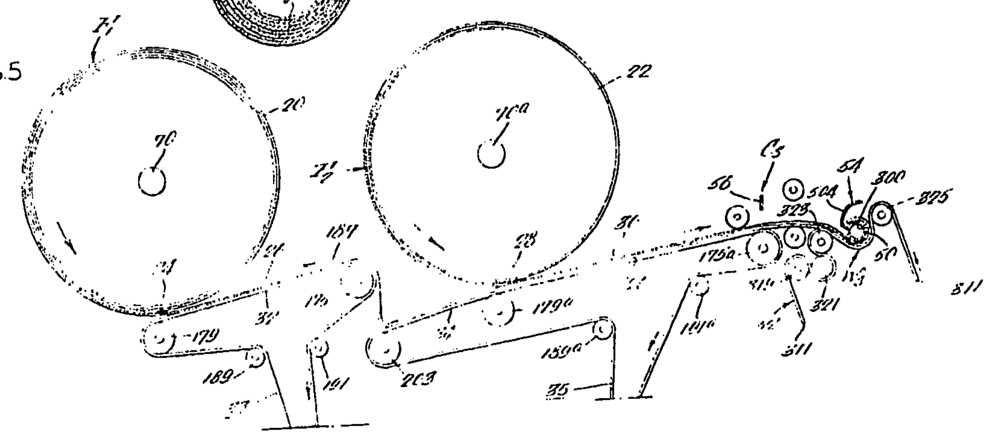
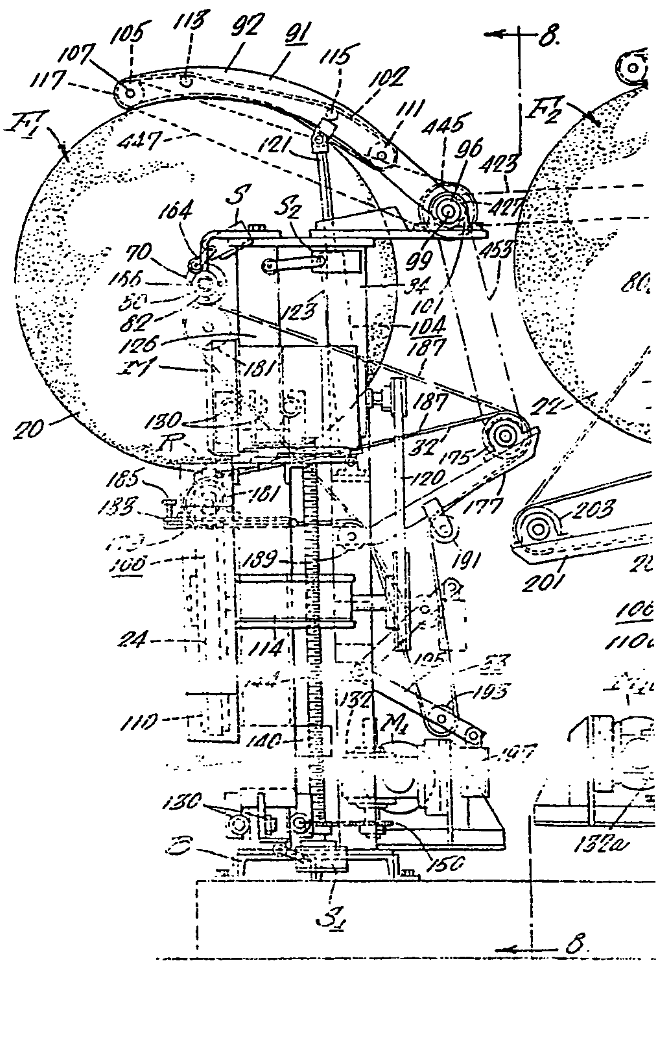


FIG.5





8
8

1214330 COMPLETE SPECIFICATION

9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG. 6.

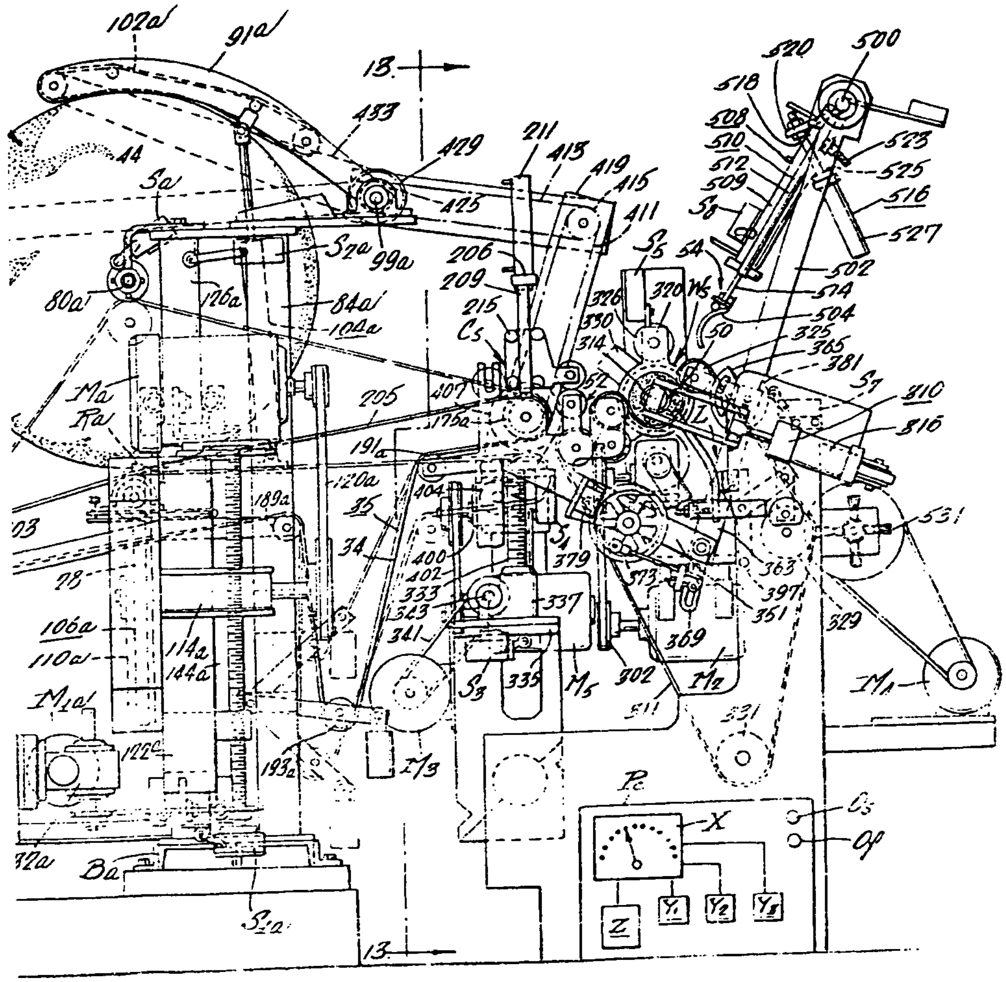


FIG. 6.

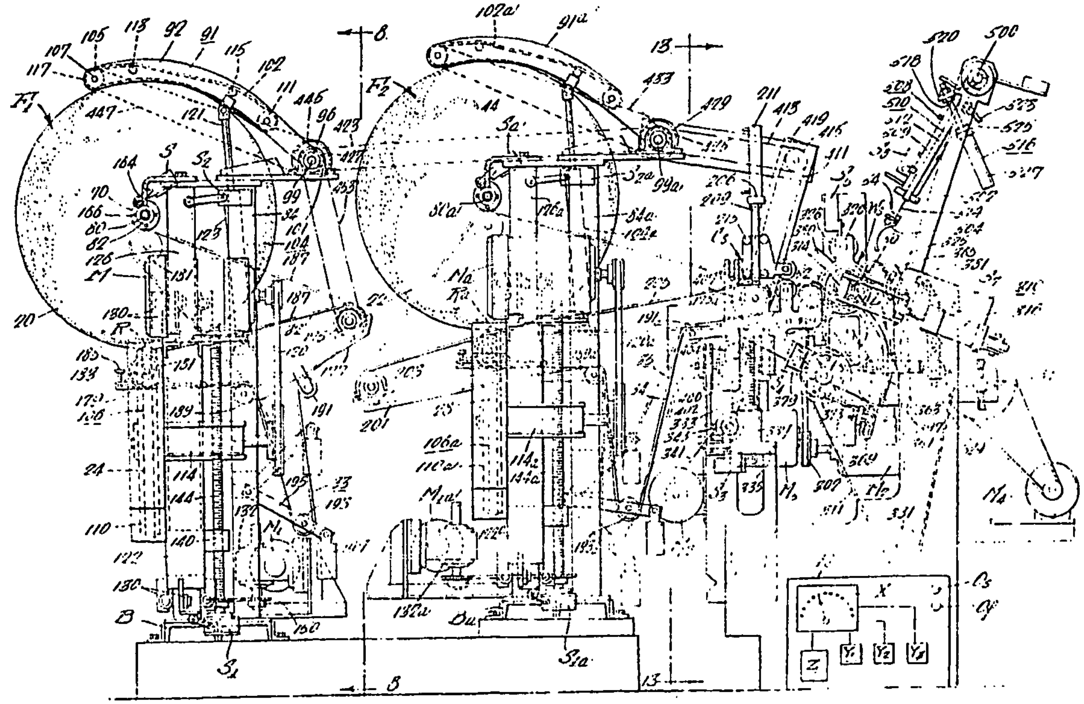
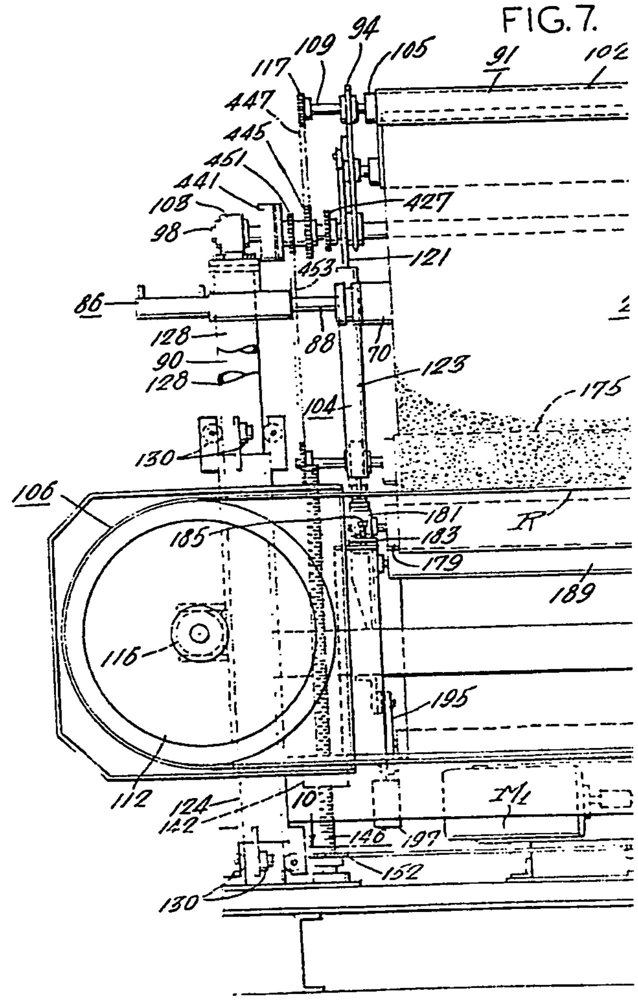


FIG.7.



117
109
94
105
91
102
447
445
451
441
108
98
427
453
121
86
88
70
128
90
128
123
175
104
130
106
181
185
183
179
189
116
195
112
124
142
10
146
197
M_L
152
130
R

1214330 COMPLETE SPECIFICATION

9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG.9.

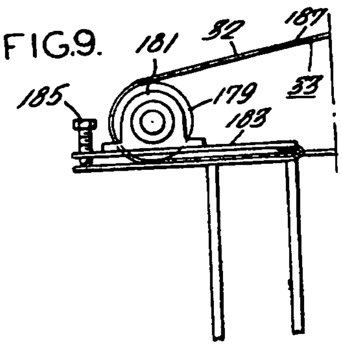


FIG.7.

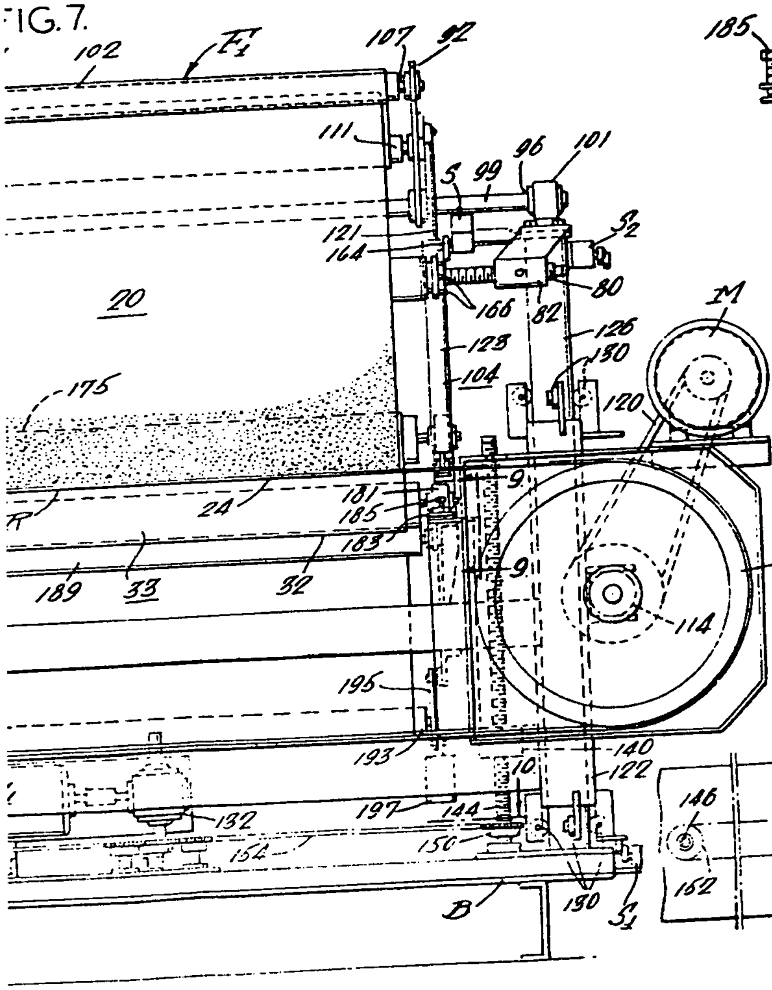
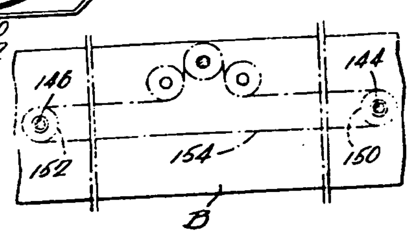


FIG.10.



1214330 COMPLETE SPECIFICATION
9 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 3

FIG. 7.

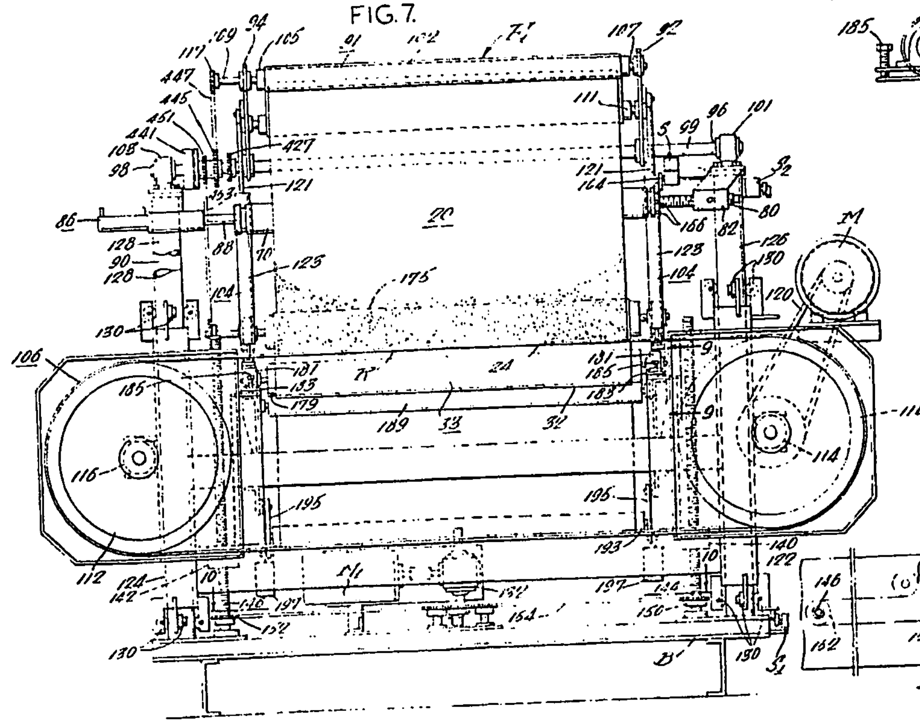


FIG.9.

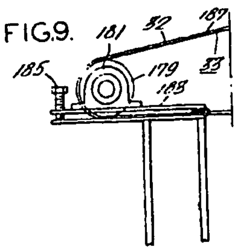


FIG.10.

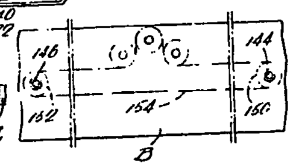
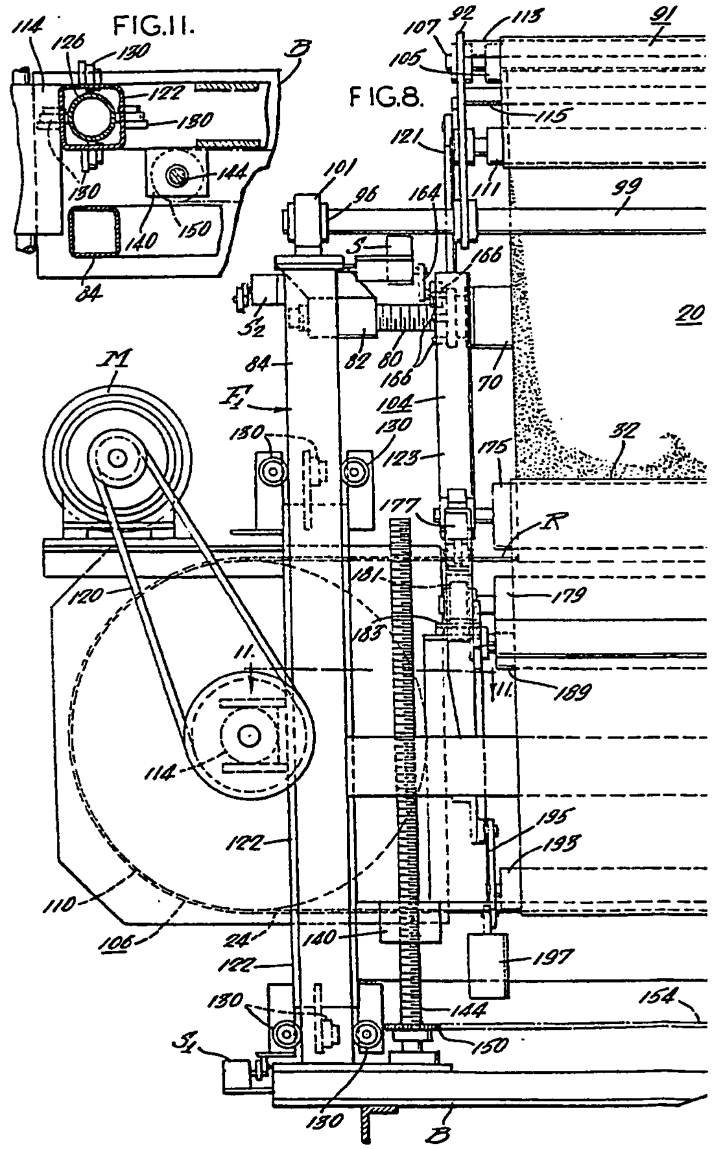


FIG.11.

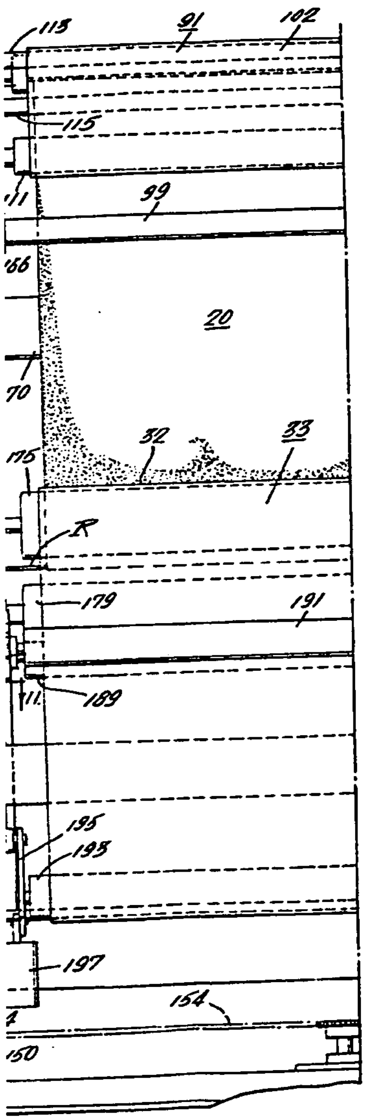
FIG.8.


114
126
130
122
130
B
130
144
140
150
84
107
92
113
91
105
115
121
111
99
101
96
164
S
166
20
S2
82
80
166
70
M
84
F1
104
130
130
123
32
175
177
R
120
181
179
183
11
189
114
122
195
193
110
106
24
140
197
122
130
144
154
150
S1
130
B

1214330 COMPLETE SPECIFICATION

9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4



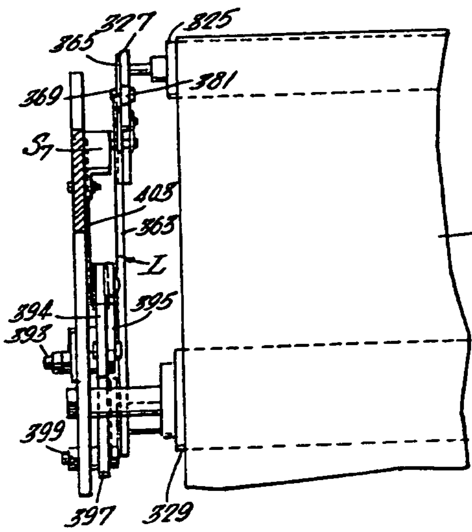


FIG.17.

FIG.16.

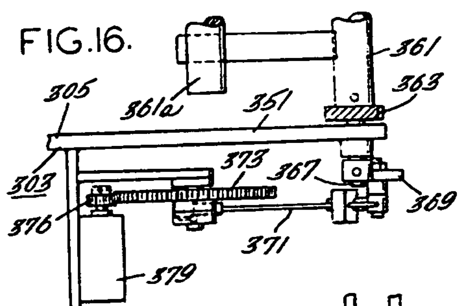


FIG.18.

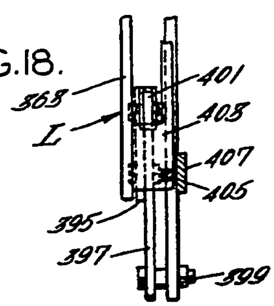
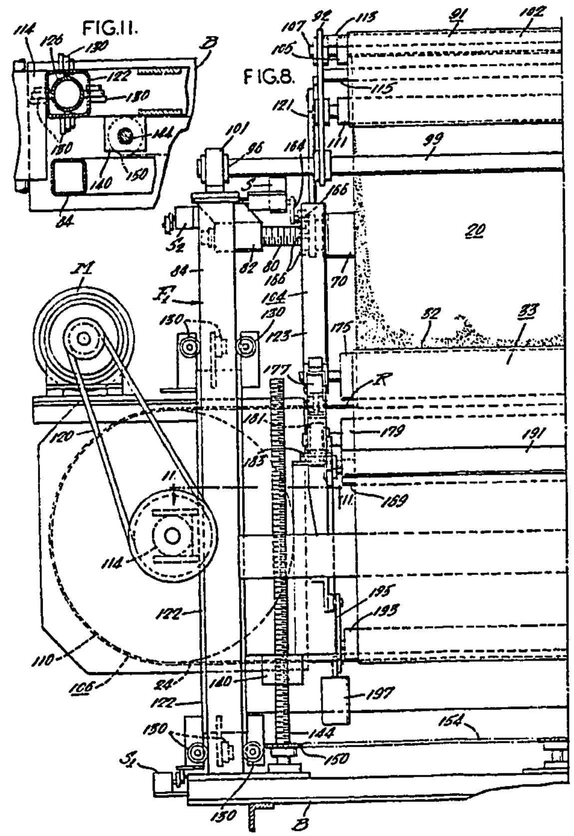


FIG.11.

FIG.8.



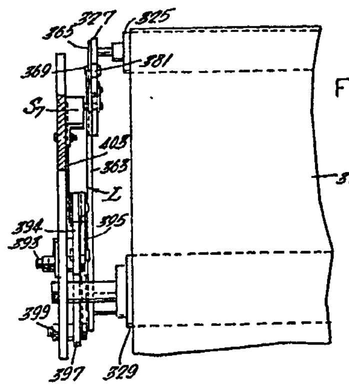


FIG.17.

FIG.16.

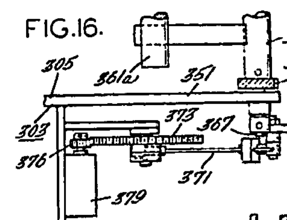
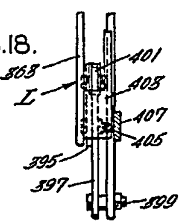
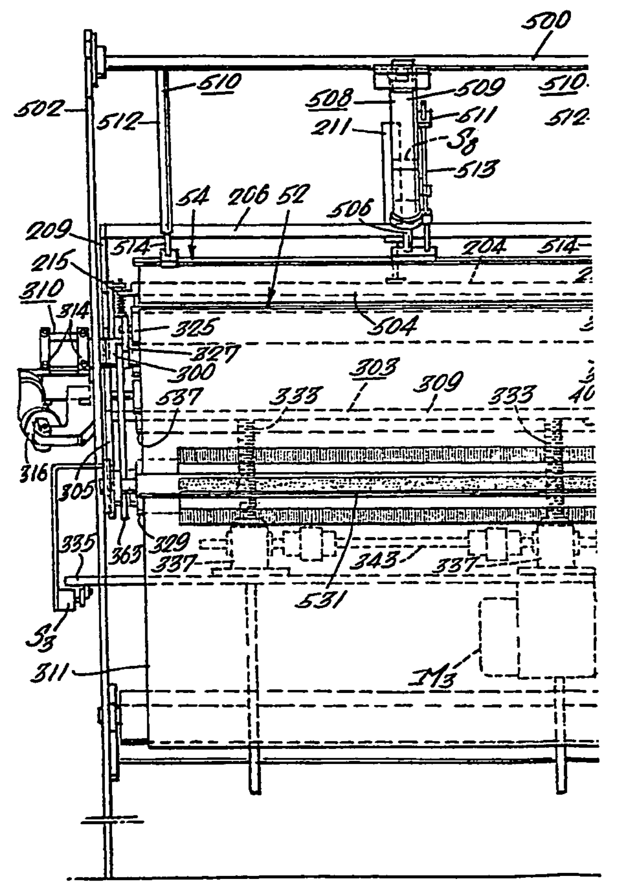


FIG.18.




500
510
512
502
508
509
511
211
S_8
513
206
52
54
506
209
514
204
215
310
314
325
327
300
504
303
309
333
537
316
305
363
329
335
337
343
531
S_3
311
M_3

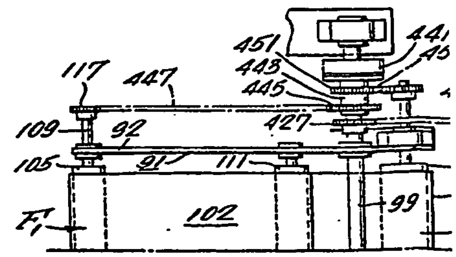

451
443
445
117
447
427
109
92
105
91
111
F_1
102
99

FIG.14.

1214330 COMPLETE SPECIFICATION
9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 5

FIG.12.

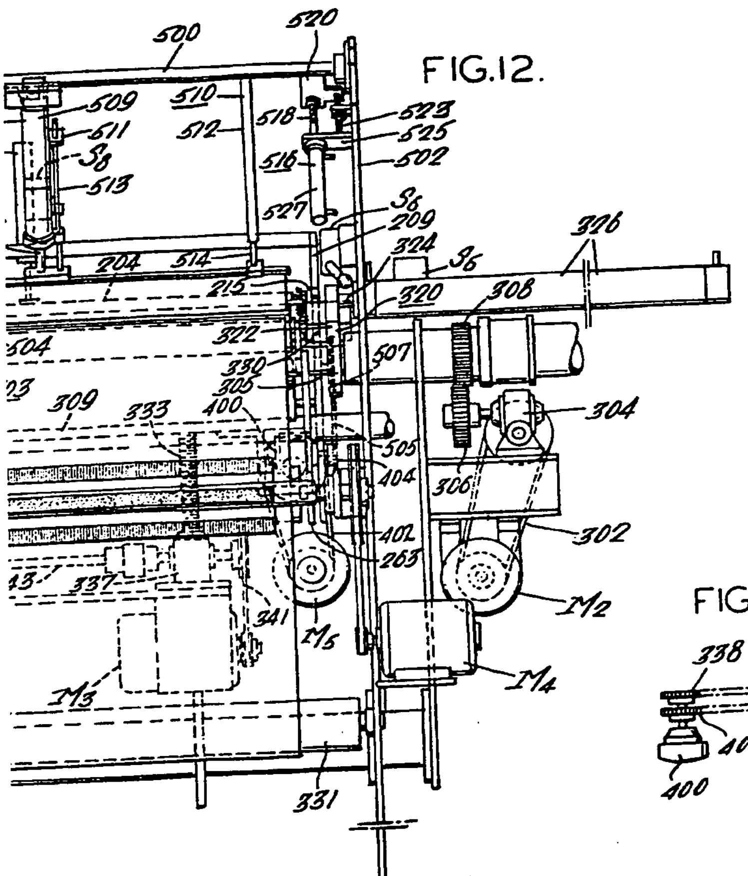
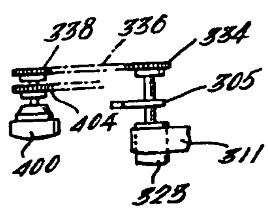
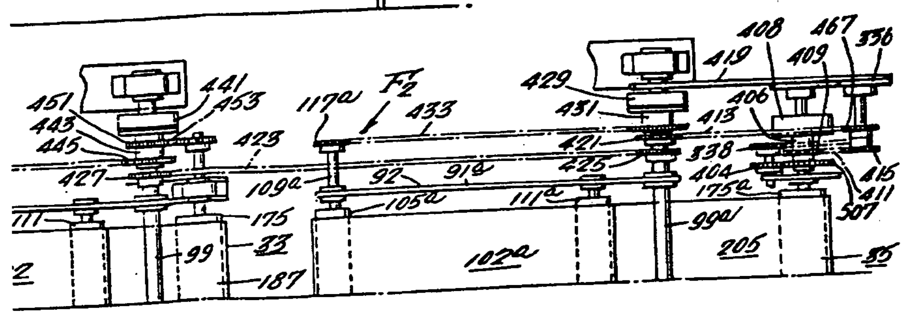


FIG.14a.





1214330 COMPLETE SPECIFICATION
9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 5

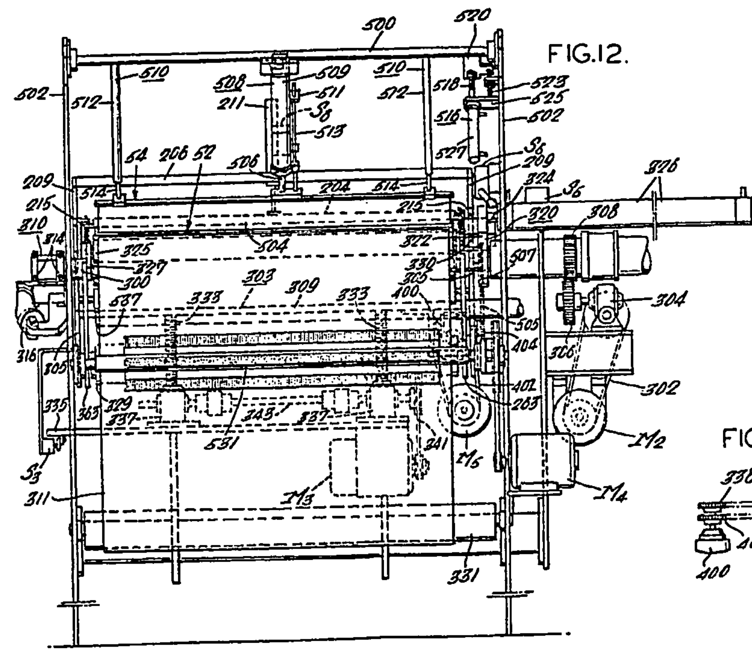


FIG.12.

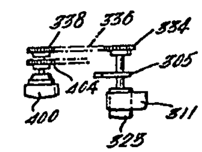


FIG.14a.

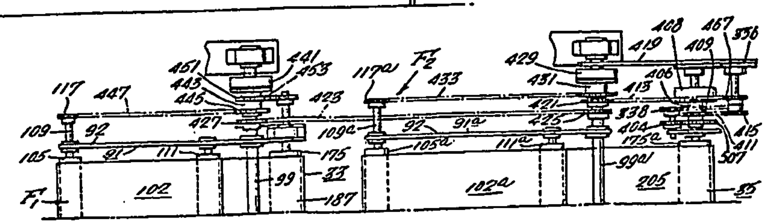


FIG.14.

FIG.13.

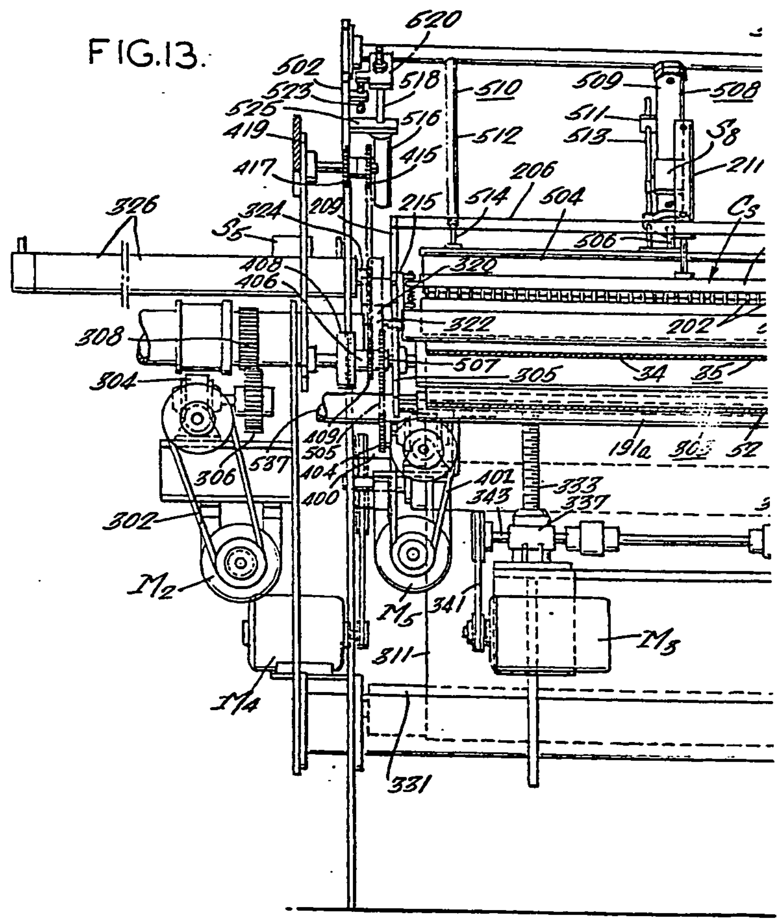
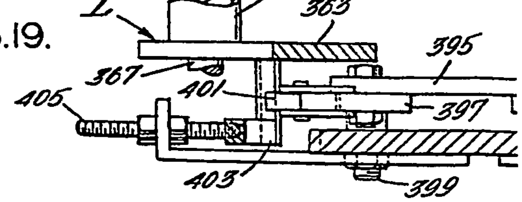
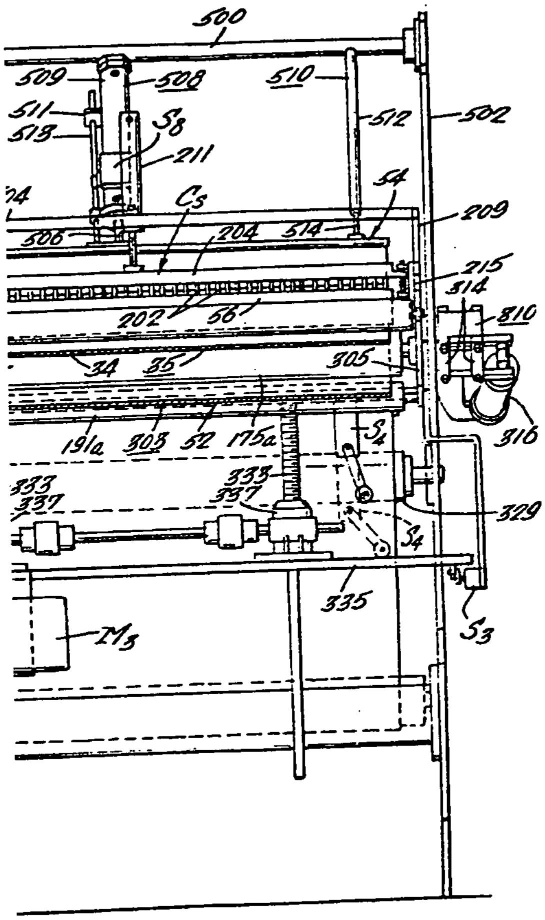


FIG.19.





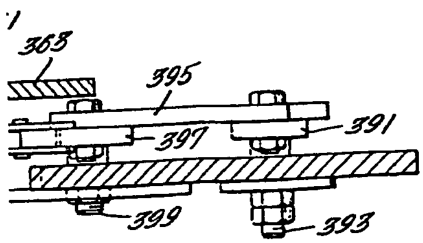


FIG.21

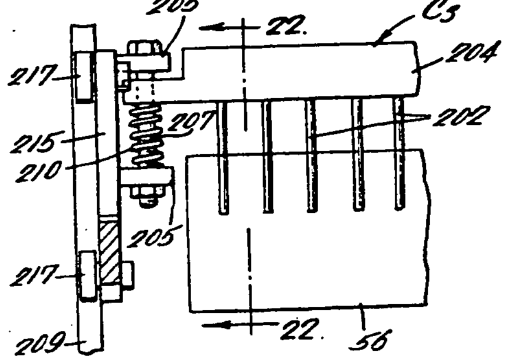


FIG. 20.

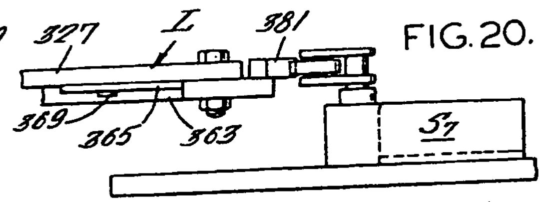


FIG. 22.

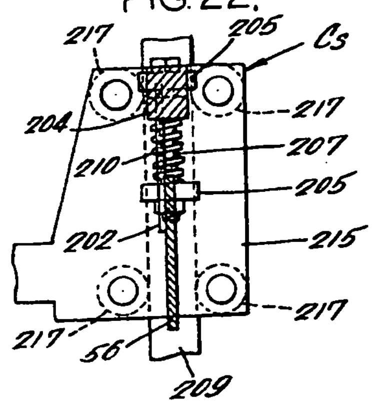


FIG.13.

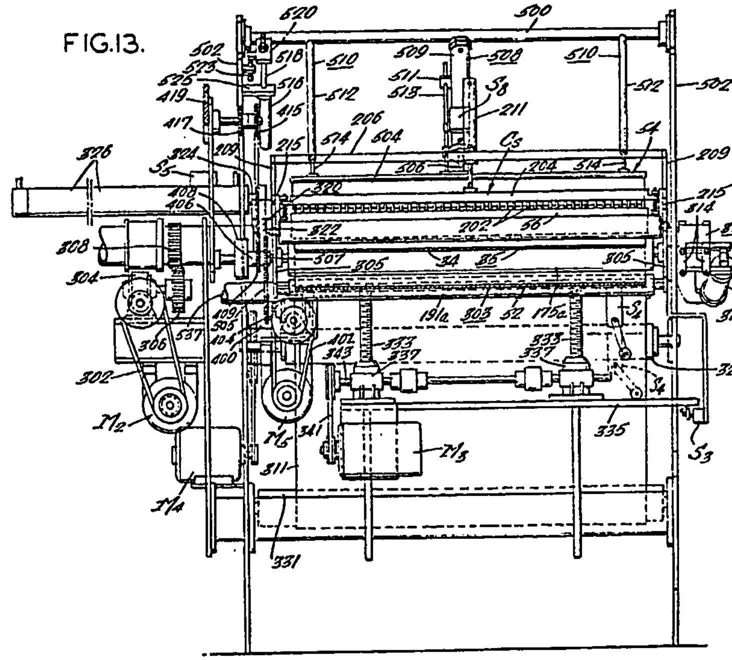


FIG.19.

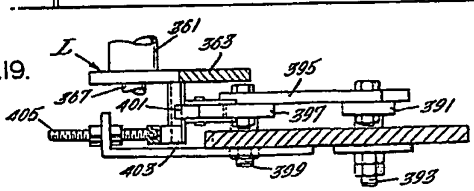


FIG.21

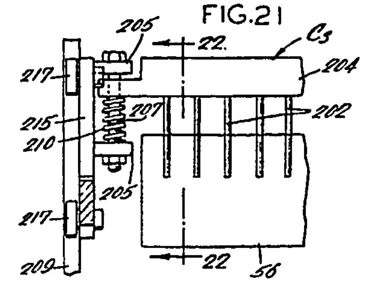


FIG.20.

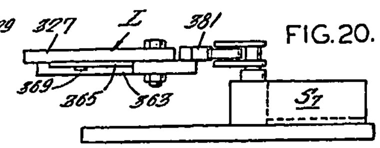


FIG.22.

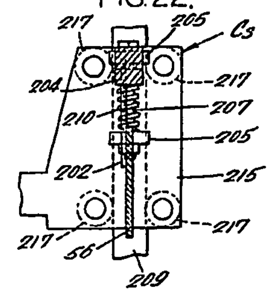
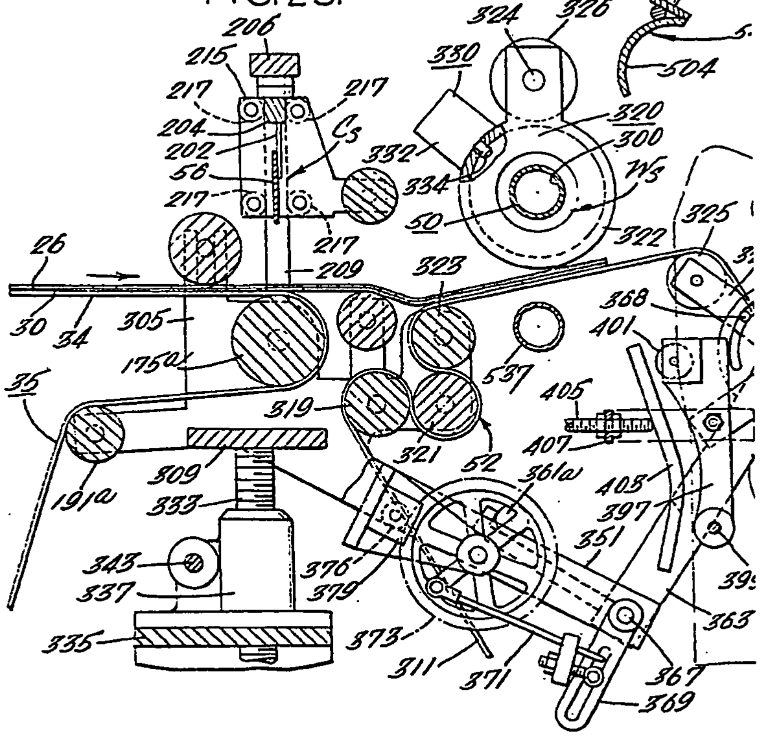


FIG. 23.


206
215
217
217
204
202
56
217
217
Cs
330
324
326
332
334
320
300
Ws
50
322
504
26
30
34
209
323
305
175a
325
368
401
537
35
319
321
52
405
407
309
333
191a
361a
403
397
351
343
337
376
379
373
311
371
367
369
363
335

1214330 COMPLETE SPECIFICATION

9 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 7

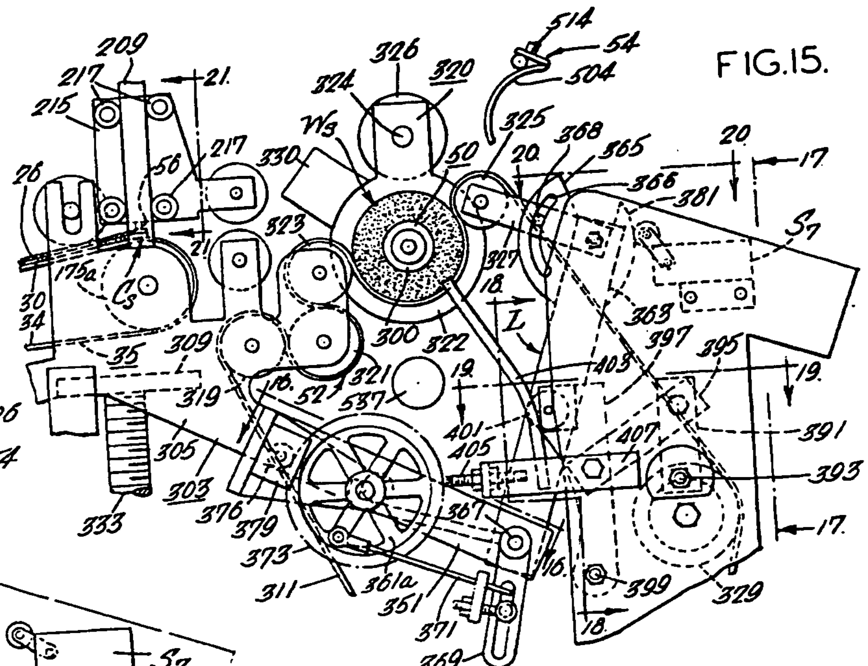


FIG.15.

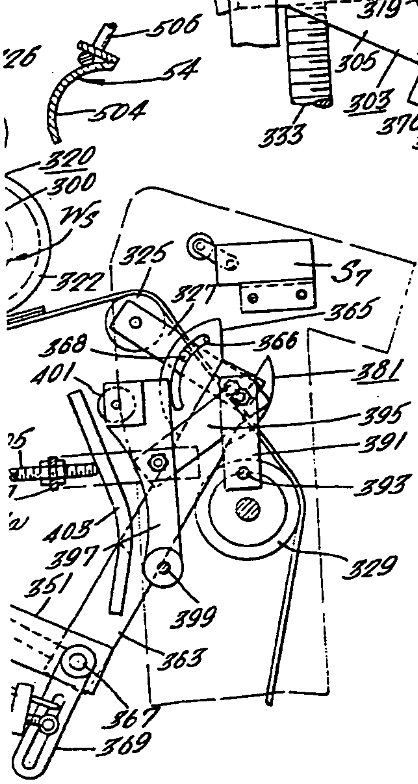


FIG31.

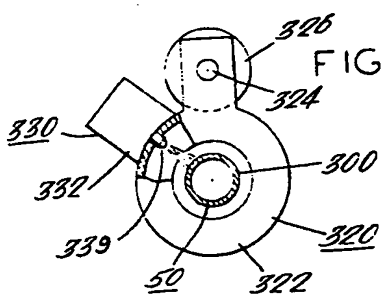


FIG.15.

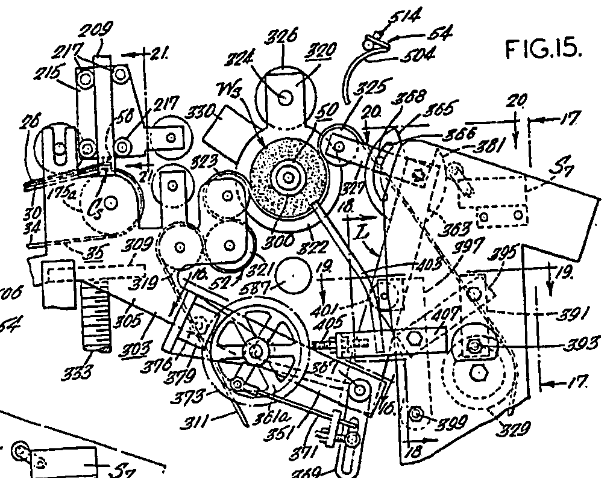


FIG.23.

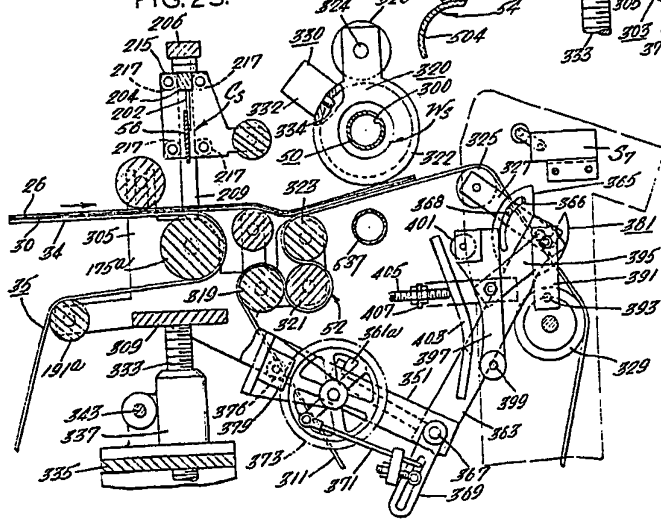
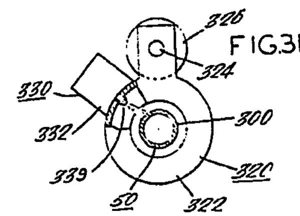


FIG.31.



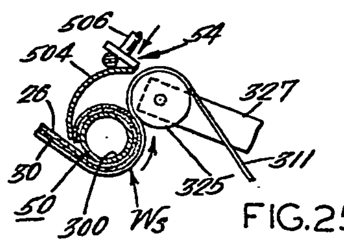


FIG.25.

FI(

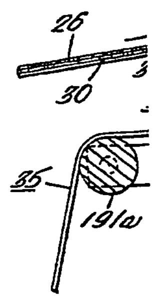
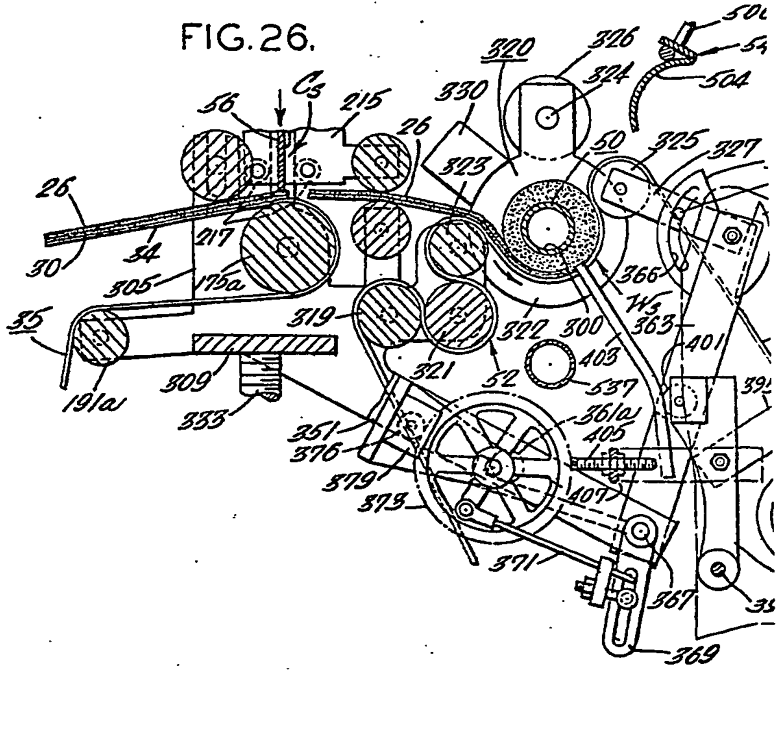


FIG.26.

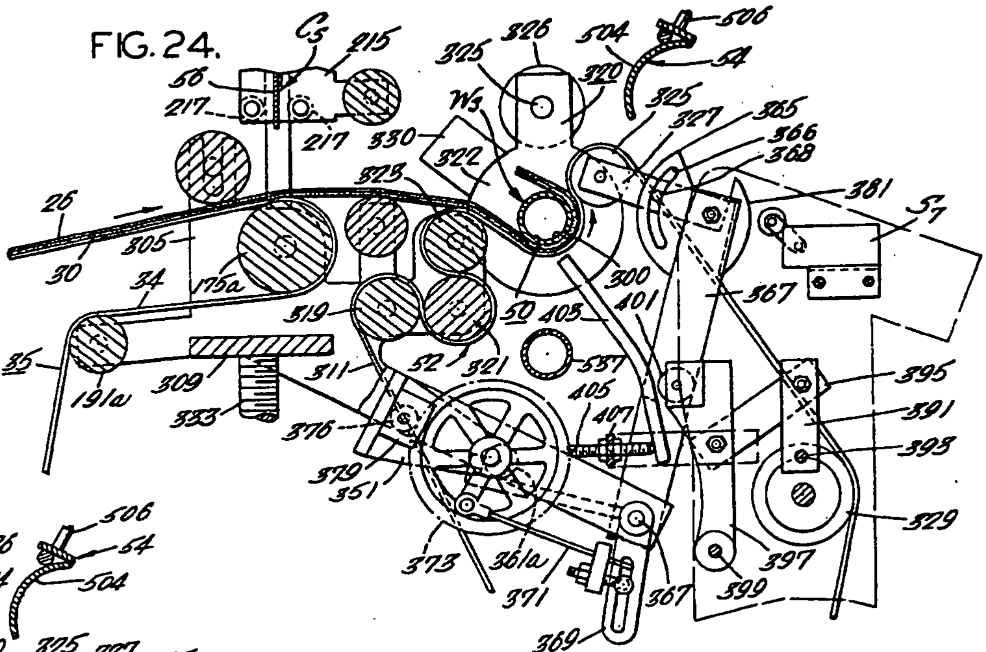


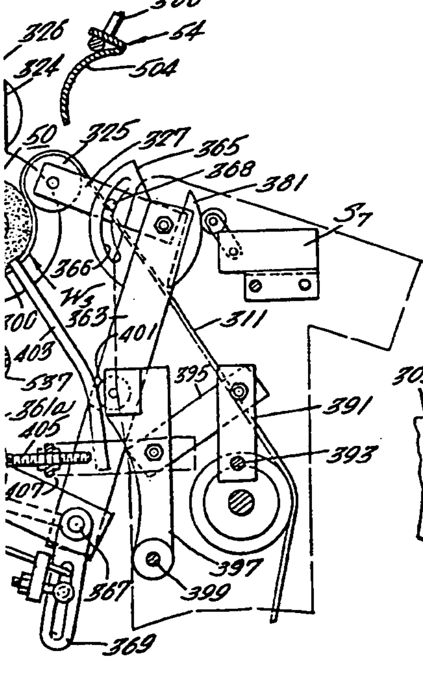
1214330 COMPLETE SPECIFICATION

9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 8

FIG. 24.





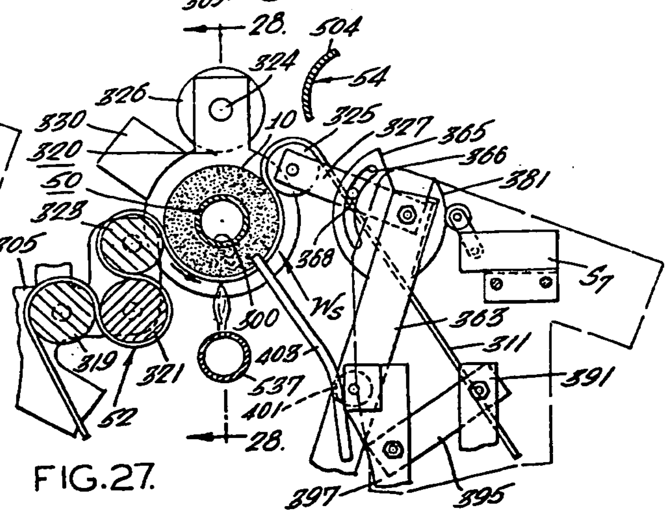
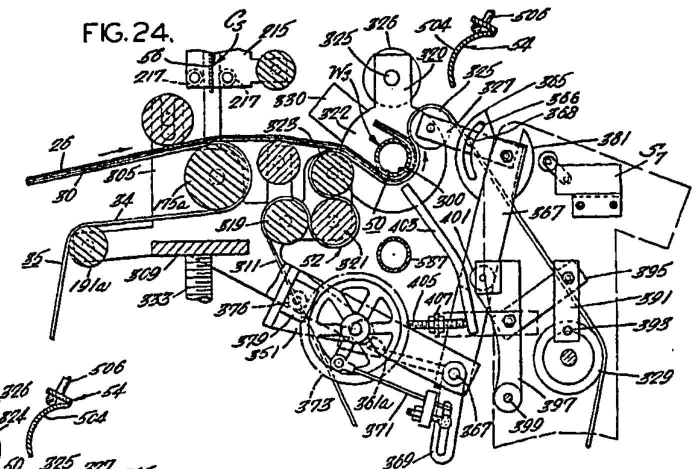


FIG. 27.

FIG.24.



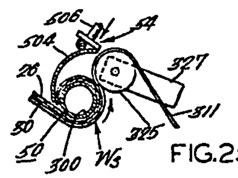
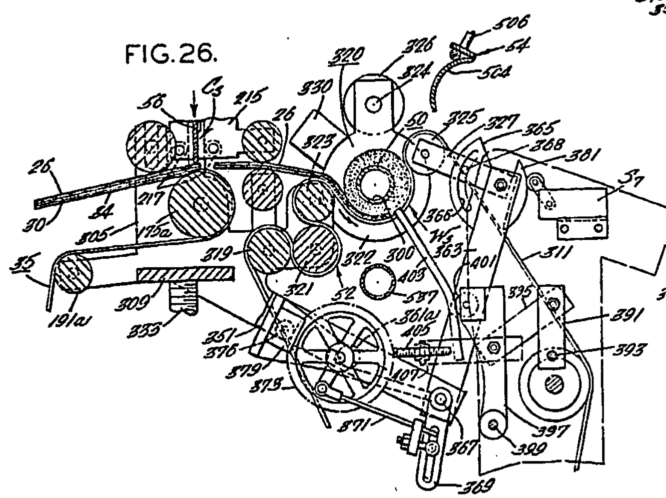


FIG.25.

FIG.26.



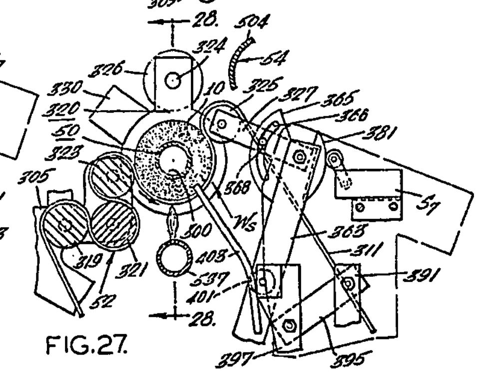
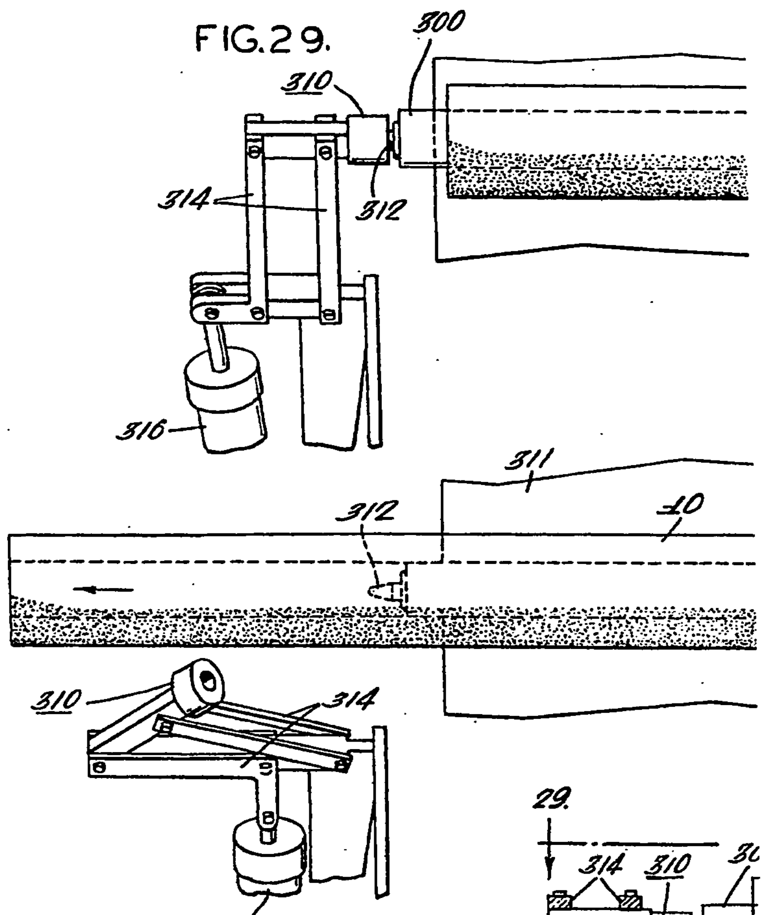


FIG.27.

FIG.29.



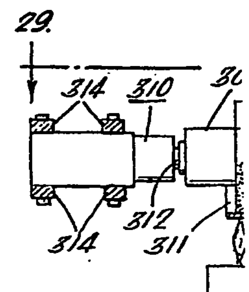


FIG.28.

1214330 COMPLETE SPECIFICATION

9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 9

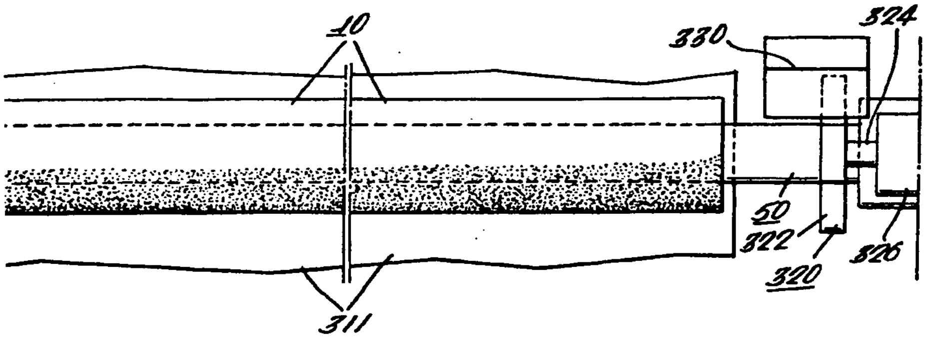
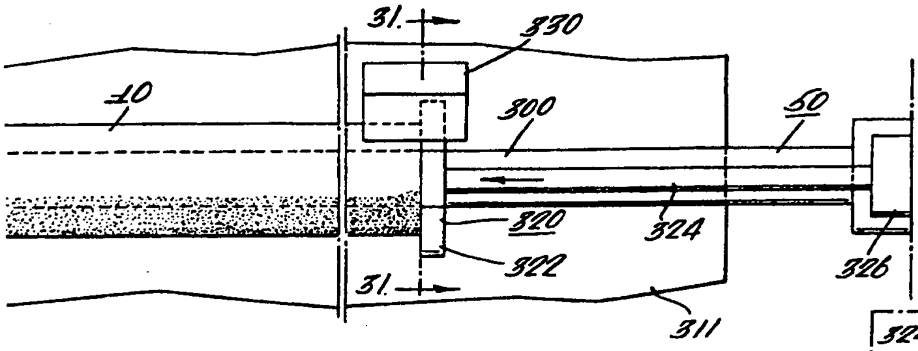
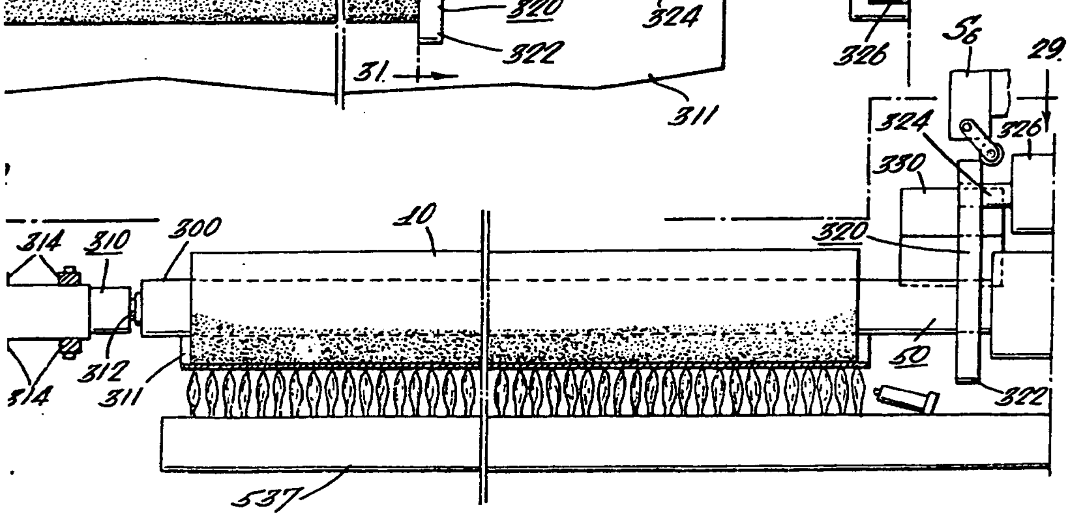


FIG.30





1214330 COMPLETE SPECIFICATION
9 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 9

FIG.29.

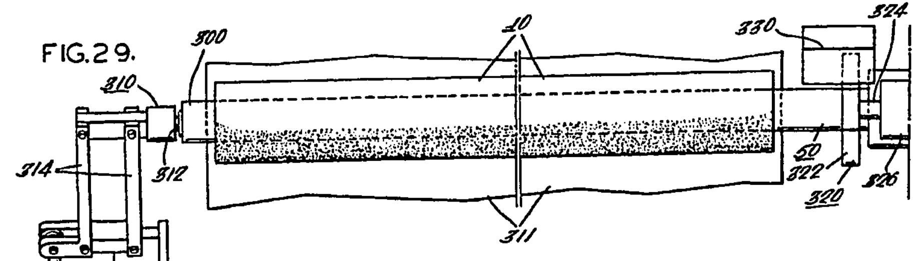
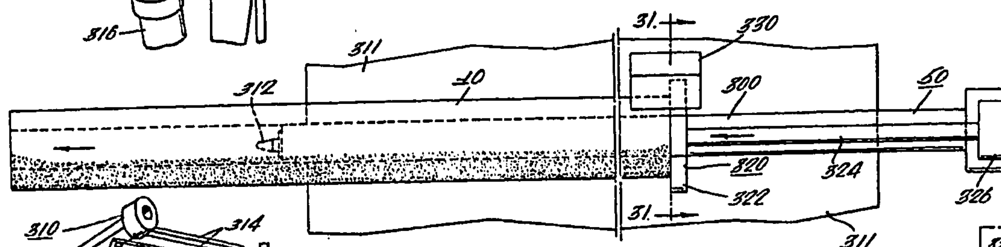


FIG.30



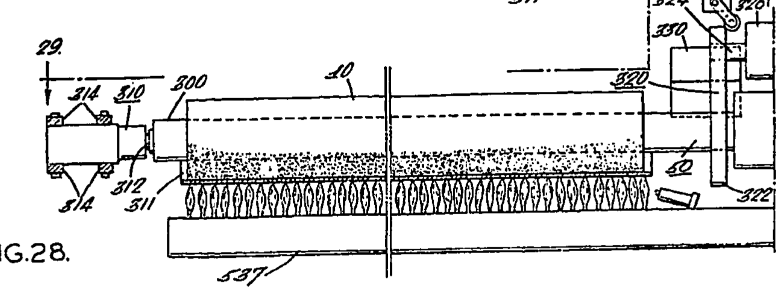


FIG.28.

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☑ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.